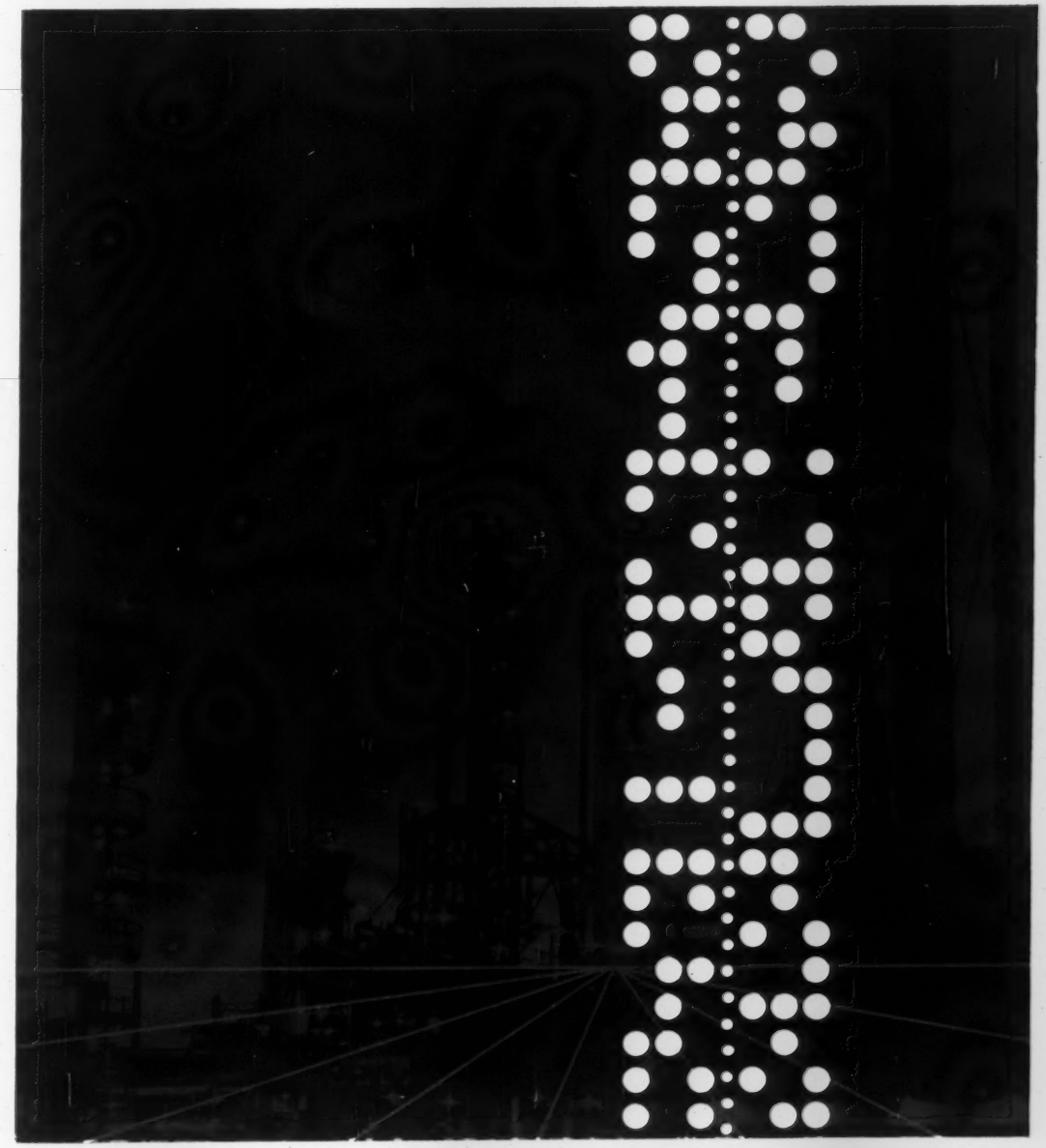
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER



JUNE 1961

in this issue:

Theory and Operation of Rotameters 1048
Data-Bloc Symbolic Logic 1052
Flexible-Disc Storage 1055
Precision Pressure Gauges 1057
Telemetry Methods 1068
Atomic Frequency Standards 1081

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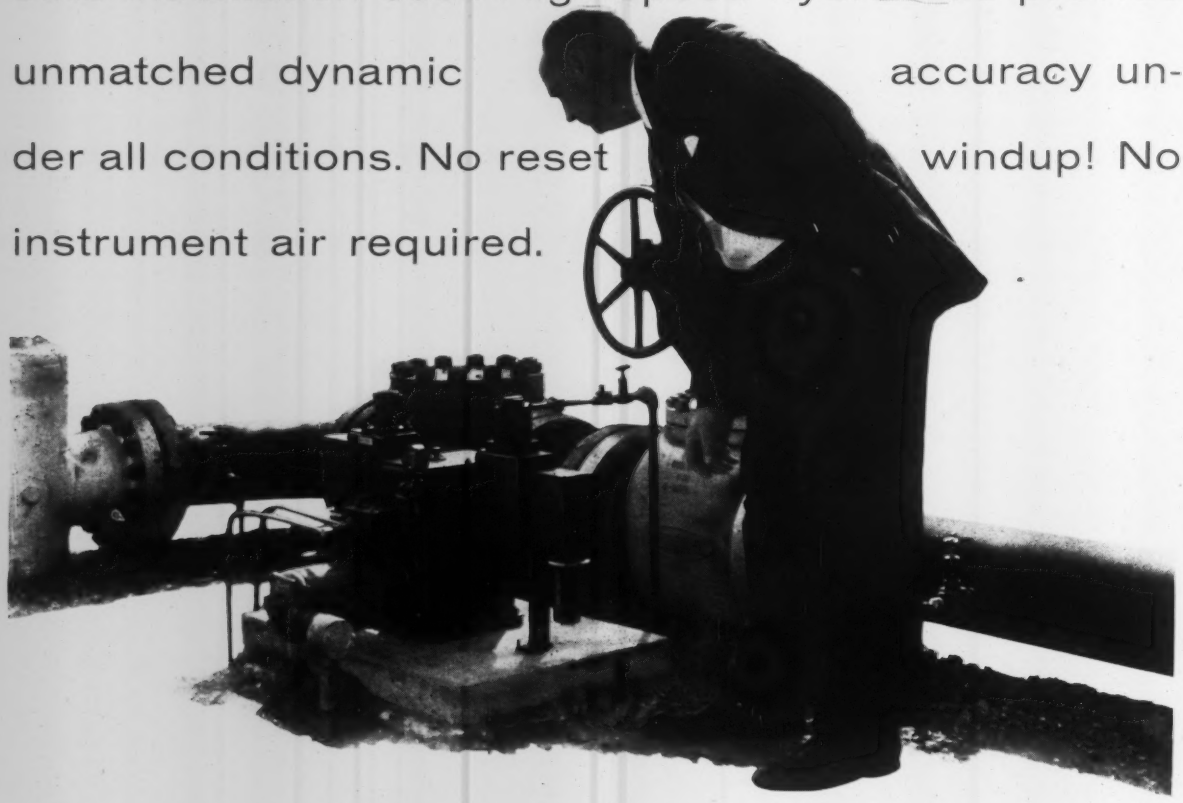

GPE controls

Write for descriptive literature

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CIRCLE 1 ON READER-SERVICE CARD

LEWIS SELECTOR SWITCHES

for RESISTANCE THERMOMETERS

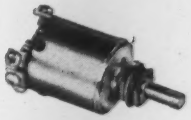
for THERMOCOUPLE THERMOMETERS

THE 9S SERIES / *The Space Savers*

Small, sturdy, steel cased switches, 1¼ inches in diameter, 2$^{9}/_{32}$ inches total shaft length, one-hole mounting with ½ inch-32 NS-2A threaded bushing. Designed especially for connecting two or more resistance bulbs to one instrument.

Part No.	Description
9S5	Single pole, four positions (with knob)
9S5B	Single pole, four positions
9S5E	Single pole, five positions
9S10	Double pole, double throw

All make before break, the instrument connected is never subjected to an open circuit during the switching operation.



1¼ INCH SIZE

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

		Switch Part Numbers	
Points	Size	Thermocouple Type	3 Wire Resistance-Thermometer Type
2	2"	11S2	36SR2
3	2"	11S3	36SR3
4	2"	11S4	36SR4
5	3"	10S5	37SR5
6	3"	10S6	37SR6
8	3"	10S8	37SR8
9	3"	10S9	37SR9
10	3"	10S10	37SR10
12	3"	10S12	37SR12
16	3"	10S16	37SR16
18	3"	10S18	37SR18
20	3"	10S20	37SR20
24	4"	27S24B2	38SR24
28	4"	27S28B4	38SR28
40	4"	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2 INCH SIZE

3 INCH SIZE

SPECIAL SWITCHES 37S6C2, Four "4-point and OFF" thermocouple switches combined in one 3" case.

The 44S Series, 2$^{9}/_{32}$ inches in diameter, shaft 2¼ inches, approx. One-hole mounting with ½ inch-32 NS-2A threaded bushing.

Part No.	Description
44S4	Six pole, double throw
44S7B	Double pole, four position
44S7B2	Double pole, double throw

For use with resistance thermometer, contacts make before break.

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

4 INCH SIZE

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

CIRCLE 2 ON READER-SERVICE CARD

SENSITIVE RESEARCH

A NEW AC VOLTAGE STANDARD

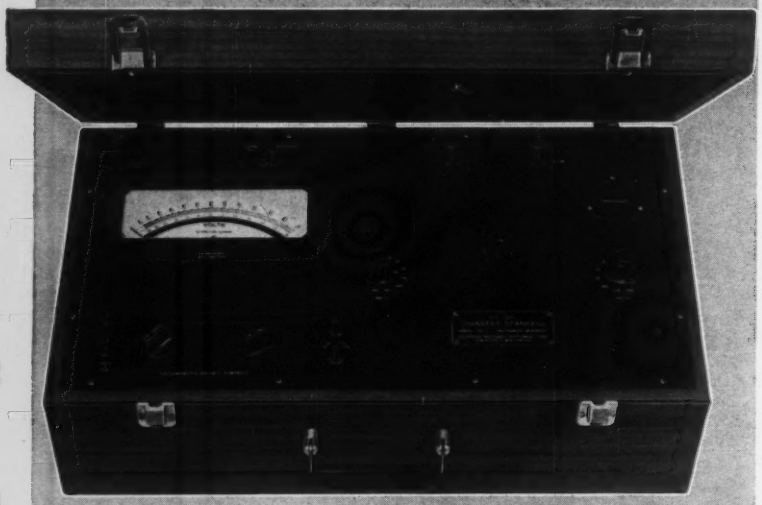
- **.01%* Accurate AC/DC Difference Measurements**
- **.013% Accurate Absolute AC Voltage Measurements**
- **Full Accuracy Over Entire Frequency Range from 20 cps — 50,000 cps**
- **True RMS Response**

FREQUENCY CORRECTIONS IN % OF READING
MODEL FLH

VOLTS	20 Kc	30 Kc	50 Kc
1.5-4.5	0	0	+.01
above 4.5-11.25	0	0	0
above 11.25-22.5	0	0	0
above 22.5-45	0	0	—.012
above 45-112.5	0	0	—.015
above 112.5-225	0	0	0
above 225-450	0	0	—.026
above 450-1125	—.027	—.038	—.069

**It is the present policy of NBS to state their maximum measuring uncertainty as ±.02%. However, they are expected to reduce this possible error to ±.01% in the near future, and the instrument is guaranteed on this basis. It is also their present practice to limit testing to 30 kc on instruments of the Model FLH's accuracy unless the user is in a position to justify that certification to 50 kc or higher is imperative. Correspondence between NBS and the user is required in such an instance.*

The Model FLH has been named in honor of Francis L. Hermach of the National Bureau of Standards in Washington, D. C., in recognition of his accomplishments in the field of AC/DC transfer measurements.



MODEL FLH

The Model FLH is a *NEW* thermocouple transfer standard designed to measure directly in percentage of reading, the influence of frequencies between 20 cps — 50,000 cps on the indication of voltmeters, calibrators, and other transfer standards over a range of 1.5 — 1125 v. It is supplied with an NBS Certificate* showing correction figures for those values of voltage where the AC/DC difference (or frequency influence) is, or exceeds, ±.01%. Typical performance characteristics are listed in the table on the left. These figures illustrate that it is seldom necessary to apply corrections to achieve substantially better performance than is basically guaranteed. Since the highest volt ranges have the greatest frequency influence, in practical usage the lower volt ranges can be considered to have either greater fundamental accuracy or a frequency span well beyond 50 kc.

The Model FLH when employed in conjunction with precision DC potentiometers and their accessories, is ideally suited for use in the certification of other AC voltage standards and the making of extraordinarily high accuracy absolute AC measurements. **An AC system accuracy of ±.013% can be obtained without difficulty** by combining the FLH with Sensitive Research "COMMANDER" Instruments such as the Dauphinee DC Potentiometer, Type 9144 (accuracy ±.001%), the NBS Volt Ratio Box, Type 9700A (accuracy ±.001%) and Saturated Standard Cells, Type 4305 and Constant Temperature Enclosure, Type 9152 (accuracy ±.001%). A "COMMANDER" Instrument Catalog is available upon request.

The basic accuracy of the Model FLH is derived from the flat frequency response of its multipliers. Long term resistor stability is of no importance. If the instrument is not physically impaired its frequency response will remain fixed indefinitely.

Replacement thermocouples are of the uncalibrated type.

ADDITIONAL SPECIFICATIONS

Accuracy using NBS correction figures: ±.01% of reading from 20 cps — 50 kc.*
Accuracy without using correction figures: ±.01% of reading to 30 kc from 1.5—450 v; ±.03% to 50 kc; ±.05% of reading to 30 kc from 450—1125 v; ±.075% to 50 kc.
Resolution: ..... ±.005% minimum.
Price: ..... $1685.00 (includes NBS Certificate and Type SR4 Galvanometer).
Terms: ..... Net 30 days, f.o.b. NBS, Washington, D. C.

Write for additional information or contact your nearest SRIC sales representative.

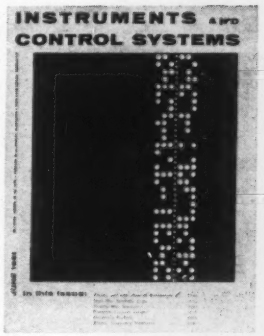
Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



TELEMETERING is subject of major emphasis this month—beginning another series on a basic field of instrumentation.

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PRINT ORDER THIS MONTH 44,700

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Theory and Operation of Rotameters 1048
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INSTRUMENTS AND CONTROL SYSTEMS

VOL. 34 NO. 6
JUNE 1961

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Automating A Complex Pipe-Finishing Operation 1077

GEORGE FRIED and ADRIAN PHILLIPS—This system calculates all basic pipe variables, sorts the pipe, and stencils the data on the pipe.

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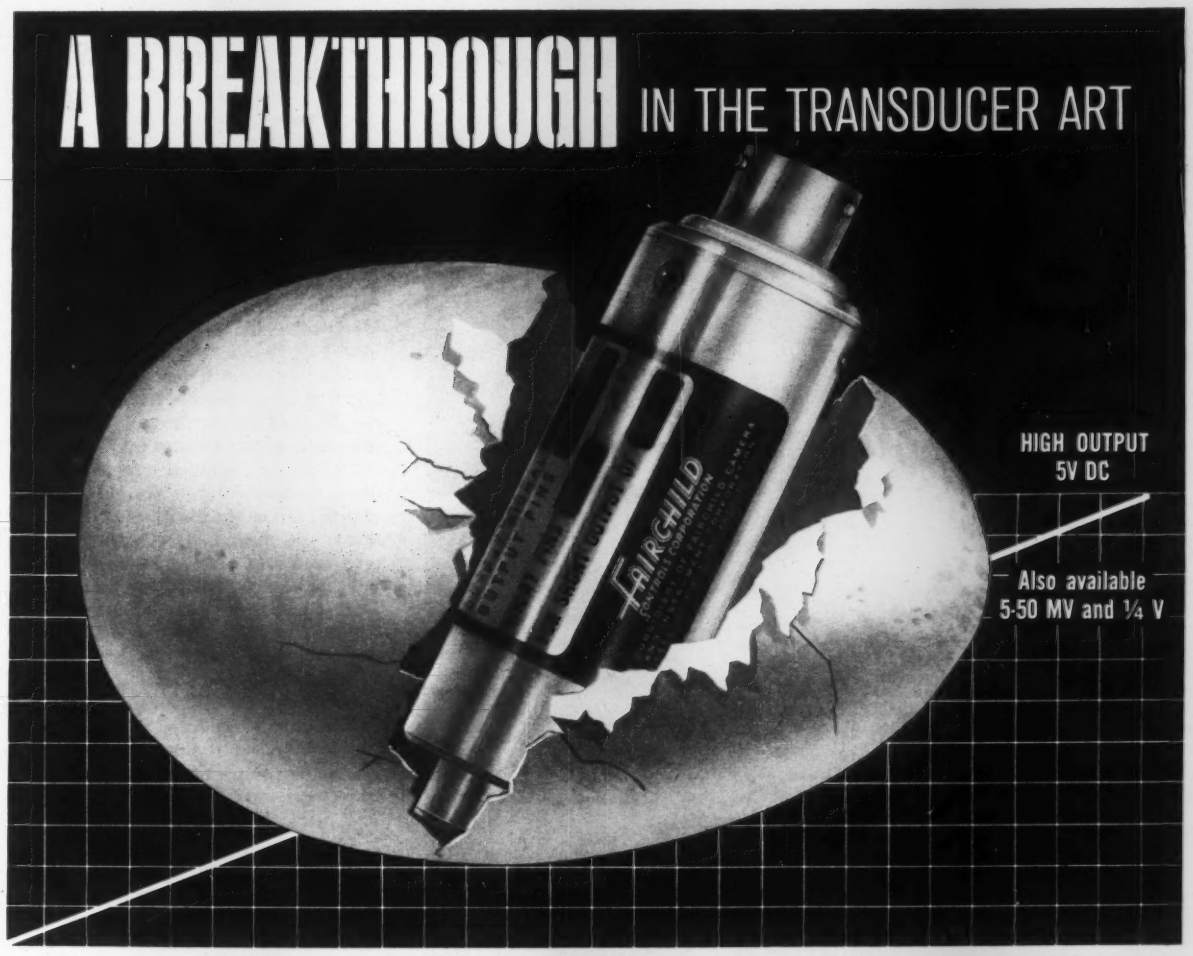
A BREAKTHROUGH IN THE TRANSDUCER ART



3S-G SILICON SEMICONDUCTOR
STRAIN GAGE PRESSURE TRANSDUCER

Outstanding features:

- HIGH OUTPUT d-c SIGNAL
- EXCEPTIONAL ACCURACY
- MAXIMUM RELIABILITY
- INFINITE RESOLUTION
- SELF CONTAINED CALIBRATION
- TEMPERATURE COMPENSATED
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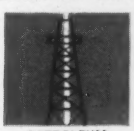
- RUGGEDIZED

The Fairchild 3S-G is the first and only pressure transducer with a 5V DC output signal that uses semiconductor materials having piezoresistive characteristics as a transducer sensing element. It is also available with low level outputs of 5-50 MV and ¼ V. This revolutionary transducer is extremely accurate, has an operable temperature range of —65° to 250°F, and is responsive to both static and high frequency dynamic pressures from 0-100 through 0-10,000 psig and psia. It is fully compatible with existing military air, ground and underwater telemetry and industrial systems and resistant to all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids and high energy fuels. Airborne and ruggedized designs are available; both can withstand 35 G's vibration to 2,000 cps with negligible effect. For information on the application of the silicon semiconductor strain gage pressure transducers to your system requirements, write to Fairchild Controls Corp. Dept. 50.

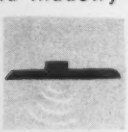
wide application in control systems for defense and industry

STEEL


PETROLEUM

CHEMICAL

MISSILE


UNDERWATER

CIRCLE 4 ON READER-SERVICE CARD

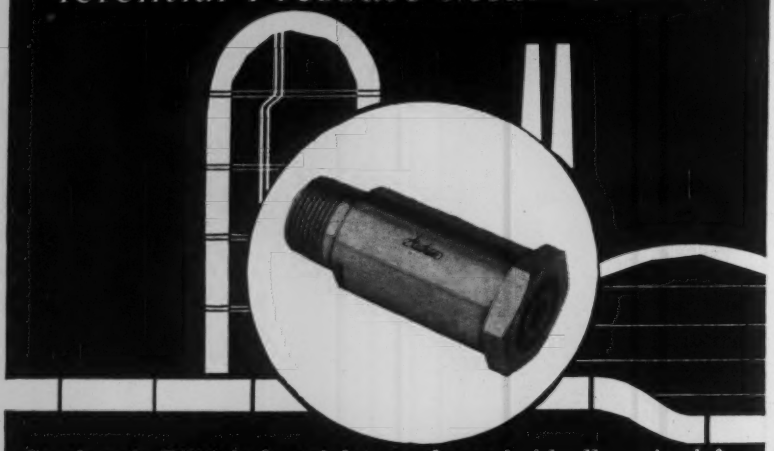
FAIRCHILD CONTROLS CORPORATION
A Subsidiary of Fairchild Camera and Instrument Corporation

GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

225 Park Ave., Hicksville, L. I., N. Y.
6111 E. Washington Blvd., Los Angeles, Cal.

NEW CONCEPT

In Process Control Instrumentation for Gage, Absolute and Differential Pressure Measurement



Statham's P713 industrial transducer is ideally suited for process flow applications in the petro-chemical, food and utility industries. This rugged and dependable instrument is electrically calibrated at the control room, eliminating field adjustments and down-time associated with conventional instrumentation. The Statham P713 features a unique "Dimensionless" strain gage principle, a major advance in gage design, which gives outstanding performance in temperature stability and long term zero drift. For the first time, the P713 offers industry a low cost, high performance electrical transmitter for control, data logging and computer systems.

CHECK THESE OUTSTANDING FEATURES OF THE P713

- Outstanding performance in temperature stability and long term zero drift.
- Accommodates standard outdoor conduit fittings.
- Tamper-proof, requires no field adjustments.
- Water-tight sealed case.
- Infinite resolution.
- Insensitivity to vibration and shock.
- Compact size.
- Ultimate in ruggedness, simplicity and reliability.

"Dimensionless" principle is described in a free 28-page booklet, "Transducers for Industrial Instrumentation." Write for your copy now.

Statham STRAIN GAGE DIVISION

Statham Instruments, Inc., 12401 W. Olympic Blvd.
Los Angeles 64, Calif. GRanite 8-0361 TWX: West Los Angeles CAL 6602

CIRCLE 5 ON READER-SERVICE CARD

I&CS LETTERS TO THE EDITOR

Editor, I&CS:

Your electrical measurements issues are most interesting, particularly the articles on basic accuracy factors. One aspect of the accuracy question has puzzled me for some time. In Mr. Brownell's excellent articles and in my E. E. courses it was brought out that to obtain electrical measurements having an accuracy of the order of 0.01%, the use of extremely precise instruments and highly skilled technique is involved. Yet in many cases routine accuracies of 0.01% or .015% are claimed for such instruments as digital voltmeters, ammeters, and ohmmeters. Accuracies of 0.001% to .005% are claimed for such components as bridges, standard resistors, decades, etc. You have only to glance through your advertising section to see what I mean.

Is sensitivity or precision being confused with accuracy in some cases, or is it possible that the generally held concept of the rigorous conditions necessary for accuracies in the 0.01% range is no longer valid?

K. C. McCartt
Universal-Rundle Corporation
Mahoningtown, Pennsylvania

Mr. Russell Brownell of Sensitive Research Instrument Corporation answers Mr. McCartt as follows:

Editor, I&CS:

The advertised accuracies of 0.01% and better for digital voltmeters stem primarily from the fact that there is no ASA (American Standards Association) or other standard for procedures in checking digital voltmeters. The C-39.6 committee of the ASA is working on such test requirements. However, at present an accuracy of 0.01% guarantee can literally mean that "at some time under certain conditions such a specification held true." No one can legally argue the point. No test specifications include such factors as sensitivity to line voltage, noise, transients, long-term mechanical and electrical stability, meaning of ± 1 digit, etc.

At present, no two manufacturers of digital voltmeters express themselves in universally acceptable terms, and the whole matter as to how they should is up in the air. In contrast, statements by standard groups and electrical instrument manufacturers

on the rigorous techniques needed for 0.01% DC measurements are more realistic.

Some electronics people who have a potentiometer with a 0.01% accuracy and a volt box with an accuracy of 0.02% or 0.04% (until recently 0.04% was the standard) combine this equipment with a standard cell of 0.01% accuracy and try to make 0.01% measurements. With this type of equipment this might be achieved, provided NBS correction curves were utilized at all times and precautions are taken in technique that would not allow for any additional errors. However, few electronic companies apply correction curves when using such standards, and few have people in their employ who know how to get the maximum capability from the equipment they are using. In some cases, digital voltmeters are being used as millivoltmeters and calibrated with potentiometers having a slide wire with as much as 30 microvolts thermal noise and zero instability.

Perhaps digital voltmeter manufacturers would not be making such claims if they were not forced to do so by competition.

Russell Brownell
Sensitive Research Instrument Corp.
New Rochelle, N. Y.

Editor, I&CS:

I'd like to thank you for your superb editorial judgement in following me from field to field. When I was primarily interested in analog computers, your *Simulation Council Newsletter* was greatly appreciated. Now that my interests have turned to precision measurements, your cooperation with the PMA is highly gratifying.

Being heavily involved in the field of precision measurements, we were favorably impressed by the wealth of good, solid information in the January issue of *Instruments & Control Systems* pertaining to this field. We certainly hope this trend will continue; this growing segment of our technology needs an effective medium of communication. Keep up the good work.

We have one correction to suggest, however. In Dr. Kelley's excellent article on "International Electrical Standards Laboratories" he states that NBS presently limits its certification on AC measuring devices to 0.05%. He further states that research is continuing on thermocouple instruments which may make accuracies of 0.01% possible.

We are pleased to report that the

hays

RAMBLINGS ON INSTRUMENTATION

MEMORANDUM

TO: President

FROM: Vice President—Sales

SUBJECT: DO FORMER MAJOR LEAGUE BASEBALL MANAGERS MAKE EFFECTIVE INSTRUMENT SALESMEN, PARTICULARLY WITH A NEW PRODUCT LIKE THE HAYS DISSOLVED OXYGEN ANALYZER?

I am not going to review all the steps that led up to the hiring of this old codger, Macey Bengle, who used to manage that big league ball club in the East. I admit I agreed at the time it was a charitable move in behalf of a nice old man who had been retired before he was quite ready.

However, the old gentleman has been on the road for two months now trying to drum up some interest in our new Dissolved Oxygen Analyzer—a red hot product if there ever was one—and I am gradually forced to the conclusion that baseball and instrumentation do not mix. Here, for instance, is a verbatim transcript of the sales talk this antique umpire baiter has been using:

"Now you take this here tank or pipe or thing in a situation like where the boiler feed-water could be getting the inside of the thing as rusty as Sal Maglie's arm and you've got to get the dissolved oxygen in there analyzed—although how the hell oxygen can dissolve in water is one for Judge Landis. So you go to the bullpen for the new Hays Dissolved Oxygen Analyzer in the clutch and it's right in there every time. Smaller than home plate, with a built-in calibration check they could use to replace umpires . . . and with a full scale range as low as 0 to 20 ppb it's as accurate as Whitey Ford with a no hitter goin'. Costs less to maintain than some of them ballparks in the Grapefruit League . . . gets rid of scrubbers, chemicals, tanks of gas . . . even hits to the opposite field. Does the trick with a galvanic cell with silver electrodes.

"Now if you folks don't want to pay cash, maybe we could get together on a little swap. How's about one Hays

Box Score on the Hays Model 625 Dissolved Oxygen Analyzer. Ranges: 20 to 100 ppb. Accuracy: 5%. Time Constant: 5 seconds. Sensitivity: 0.1 ppb.

Dissolved Oxygen Analyzer for a shortstop who can hit and a left hander who can put out a fire in the late innings?"

This is not exactly the type of technical presentation our customers are used to.

However, it is not the jargon that I object to. The thing that's driving us nuts in the sales department is that this old boy is selling Hays Dissolved Oxygen Analyzers like crazy! He has sold them to every ballpark in the major leagues and when last heard from was starting on the Three Eye League. Our stock of spec sheet No. 625 on the unit is getting low and the morale of our sales organization is, frankly, going to pot.

So, as I see it our choice is clear: 1) we can send our elderly friend back to manage his bank and start selling dissolved oxygen meters the hard way, i.e., to power plants and the process industries, or 2) we can issue a plug of chewing tobacco to all our salesmen and become the biggest supplier of Dissolved Oxygen Analyzers to the baseball industry.

P.S. Also you might advise me what to do with the thirteen utility infielders and two sore-armed relief pitchers we have taken in trade.

MEMORANDUM

TO: Vice President—Sales

Sales are sales! Now get out there and pitch batting practice.

Phil A. Sprague

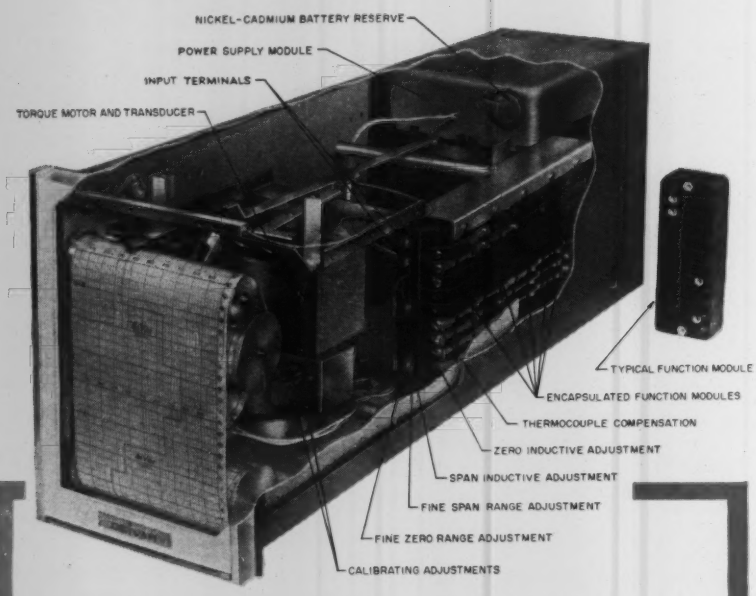
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 6 ON READER-SERVICE CARD

NEW TRANSISTORIZED
MINIATURE RECORDER OFFERS

DC INPUT ISOLATION AND NOISE-FREE DC OUTPUT



The unique DE VAR potentiometer/receiver recorder is particularly suited for Strain-Gage Transducers, Thermocouples and Resistance Bulb Elements. The isolated input circuit rejects high common-mode noise without resorting to input balancing. The DC output signal is sufficiently noise-free to feed data loggers or computers. In addition, a low noise, high frequency carrier signal is available for drift-free operation of controllers and alarms.

- Exclusive inductive zero and span adjustment — continuously variable from 0-5 mv to 0-50 mv.
- Complete solid state circuitry — including unique transistor chopper.
- Battery reserve — eliminates costly down time.
- Full scale rectilinear writing — with 1, 2, or 3 pens.

Our Technical Bulletin R-301 describes the most advanced miniature recorder now available —

Write today

DE VAR SYSTEMS INC.
494 GLENBROOK ROAD
GLENBROOK, CONNECTICUT

A DIVISION OF GENERAL KINETICS CORPORATION

CIRCLE 7 ON READER-SERVICE CARD

Holt Instrument Laboratories (Oconto, Wisconsin) Model TV-1 Thermal Transfer Standard has now been certified by NBS to an accuracy of 0.02%. Furthermore, NBS has advised that as soon as their new screen room is in operation, in about six months, they anticipate being able to certify this instrument to 0.01% up to at least 30 kc.

In fairness to Dr. Kelley, it should be pointed out that this certification probably occurred after his article was written, which is one more indication of the speed with which this technology is changing. This is a major break through in AC measurement, and we are quite proud of Holt; this is a five-fold increase in fundamental measurement accuracy, and as such is significant news to your readers. I'm sure you can bring this new to them with your normal skill in avoiding commercial bias.

A. James Edwards
W. K. Geist Company
Los Angeles 39, Calif.

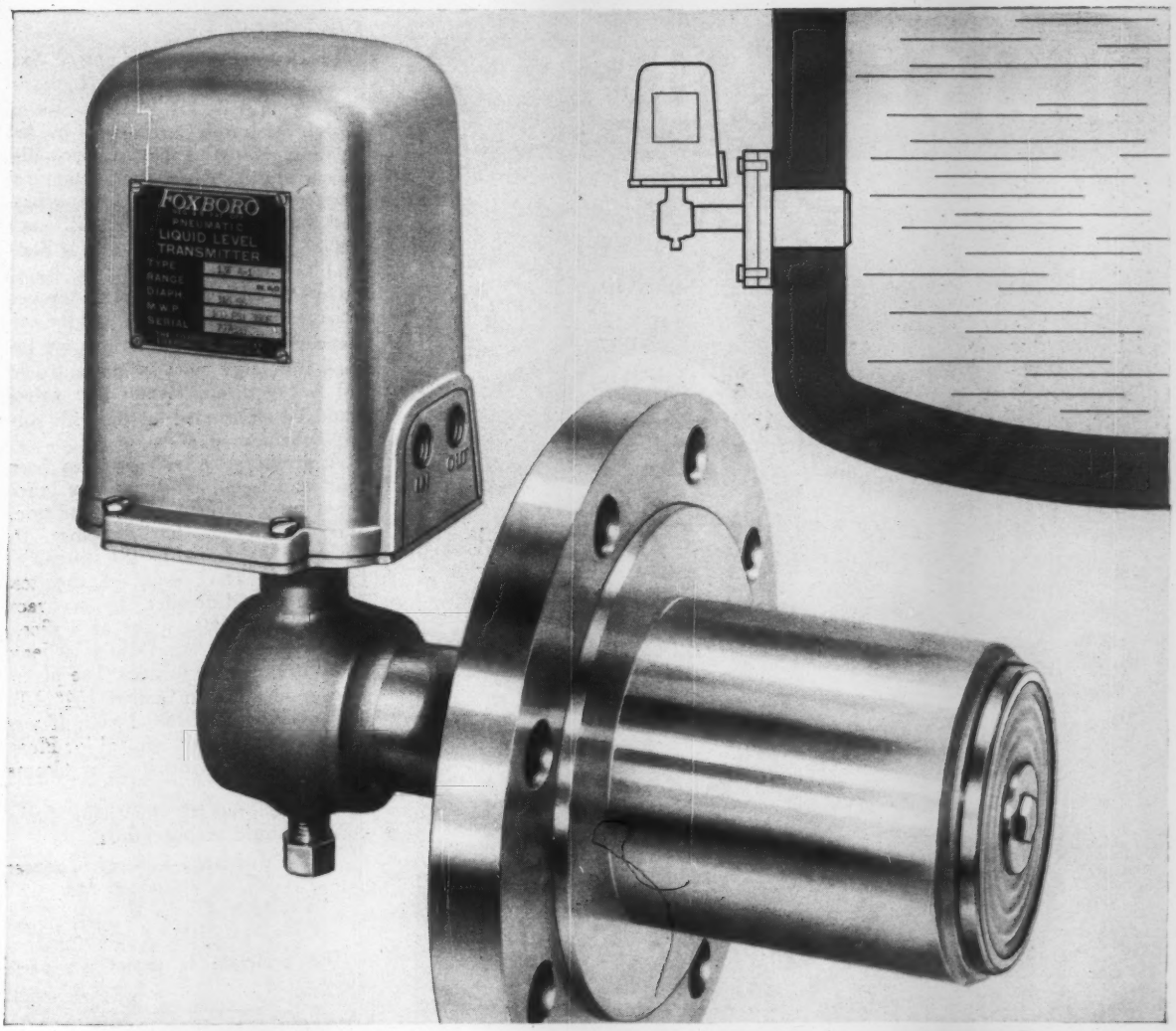
Editor, I&CS:

In the April, 1961, Letters to the Editor columns I ran across this letter from Mr. Dan N. Hendricks Jr. (on the Engineers and Scientists of America). I wish to make the following observation:

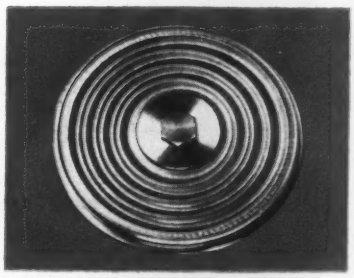
Any engineer or scientist who is worth the title could not possibly conform with Mr. Hendricks' philosophy for a national bargaining society of engineers and scientists. The only way for an engineer or scientist to achieve that which he is entitled is by hard work and selfless devotion to his profession. No national society can or should decide how far he should advance, or how fast, when the merit of his job and calling calls for him. Anyone who permits such a society to judge his advancement is either lazy, incompetent or just plain crazy. Engineering is a profession and not a craft. Craftsmanship does not enter into engineering, but ingenuity does. A craftsman does as the engineer directs, therefore an engineer cannot be held back by restraints put on him by craftsmen. The sure way for an engineer to lose his identity is to associate with an organization which directs his every move, as in a bargaining group.

Warren E. Jackson
Director of Research
Chemat-Phy Research
Port Arthur, Texas

Mr. Jackson reflects majority opinion. Proof: the ESA died on the vine.



introducing Foxboro's new extended diaphragm liquid level transmitter... designed especially for thick-wall tanks



SENSING DIAPHRAGM CAPSULE has all wetted parts of Type 316 stainless steel, with optional plastic coating for further protection against build-up of "sticky" liquids on capsule.

Here's an improvement guaranteed to please any processor who wants a flange-mounted liquid level transmitter for thick-wall tanks and pipelines. It's Foxboro's new "extended diaphragm" d/p Cell* Transmitter.

The sensing diaphragm capsule extends right through tank walls and lagging — up to 6 inches. Troublesome, catch-all pockets are eliminated. No chance for solids to build up — no need for purging or cleaning.

And you'll find the T/13 FA "extended diaphragm" d/p Cell just as reliable as the standard Foxboro flange-mounted transmitters. Direct 3-15 psi air output signal (no need for intermediate signal converters) . . . accurate, troublefree. Ideal for viscous or corrosive fluids, slurries, and solids in suspension — as well as easy-to-measure fluids.

Write for Bulletin 13-22. Or ask your nearby Foxboro Field Engineer for all the details. The Foxboro Company, 466 Neponset Ave., Foxboro, Mass.

Reg. U.S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.

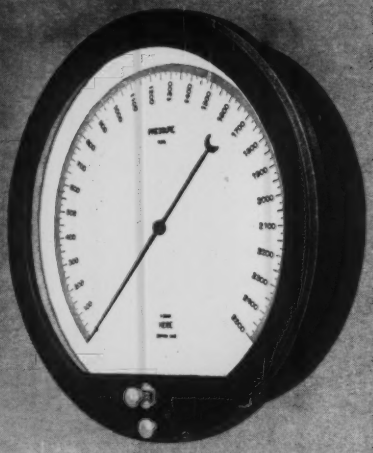
CIRCLE 8 ON READER-SERVICE CARD

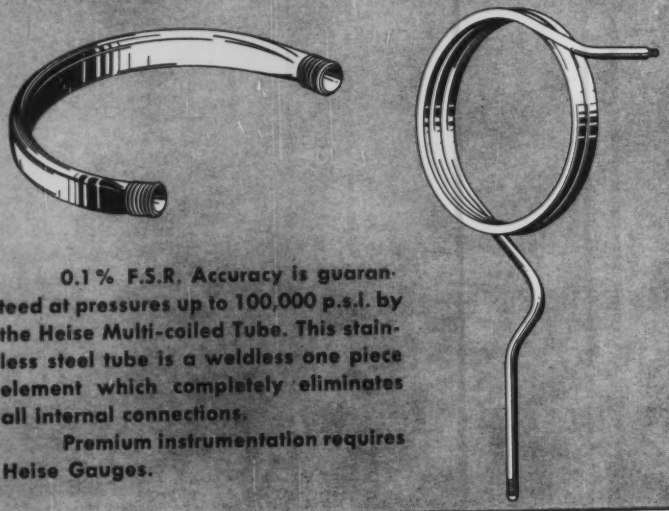
HEISE GAUGES

Corrosion Resistance

IN ULTRA HIGH PRESSURE INSTRUMENTS

Modern laboratory applications frequently require resistance to corrosive and semi-corrosive fluids as well as peak performance in ultra high pressure ranges. Heat treated 403 Stainless Steel, in an exclusive weldless Bourdon tube, provides superior service under the most critical conditions. Heise Gauges are frequently specified for use with mercury as a pressure medium.





0.1% F.S.R. Accuracy is guaranteed at pressures up to 100,000 p.s.i. by the Heise Multi-coiled Tube. This stainless steel tube is a weldless one piece element which completely eliminates all internal connections.

Premium instrumentation requires Heise Gauges.

Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

DELIVERY — 2 WEEKS FOR MOST RANGES — PRICE F.O.B. NEWTOWN

Request Catalog for SPECIAL FEATURES

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BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 9 ON READER-SERVICE CARD

Editor, I&CS:

In *Instruments and Control Systems*, April, 1961, page 671, is an article entitled "Regulator Station Design for Large Customers," by Art Fleming. Many of the problems discussed in this article, such as natural frequency and aerodynamic vibration, can be eliminated by our "Vari-Valve" venturi profile with "Flex-Trol" control elements.

One Vari-Valve can replace the two in series shown in Figure 3 of the referenced article. In addition, we believe the other parallel pairs would not be required. Hence five valves could be eliminated, along with subsequent maintenance.

A prototype Vari-Valve has been built and tested. The unit was fabricated under Model Shop conditions and delivered to our customer. Its accuracy was tested by the Bureau of Standards. The result of the test showed no difference in accuracy when compared to a set of orifices. This means that our valve is at least as accurate as the orifices. The prototype model has an actual 1¼" I.D. and operated at 3,000 PSIG. It was used as a gas supply control for Blowdown testing facilities on a plasma jet.

We are presently inquiring for a joint manufacturing effort.

Carl Johnson, General Manager
Physics for Industry, Inc.
Rochester 17, N. Y.
P.O. Box 8108

The principle is shown on page 1040.

Editor, I&CS:

I will begin teaching a new vocational course in "Electronic Instrumentation Service and Maintenance." I would appreciate suggestions or a list of texts which will aid in setting up an ideal instrumentation course of this type.

This course is to be presented as a six hour laboratory course, two nights per week, three hours per session, for a period of one year. I plan to start with the function, service, maintenance, and calibration of oscilloscopes, power supplies, meters, generators, etc.

H. C. Carpenter
Mt. San Antonio College
Walnut, Calif.

We suggest the following material available from Instruments Publishing Co. as useful in your electronic instrument maintenance course;

"Handbook of Electrical Measurements" (available with subscription to *INSTRUMENTS AND CONTROL*

SYSTEMS), covers basic electrical instruments and applications, and shows what instruments go into a calibration center.

"Electronic Circuitry for Instruments & Equipment" by Aronson, Instruments Publishing Co., $2—covers fundamentals of electronics and basic measuring techniques, and is a home-study-course with multiple-choice questions on each chapter.

Other books available include "Strain-Gage Instrumentation," "Weight Instrumentation," "Digital Techniques," "Process Control Handbook," etc.

Editor, I&CS:

Here is your questionnaire (and special subscription offer).

In turn I will make you a very special offer. Send me a money order for five dollars and I will enter your order for twelve of our Iowa crab apples ($1.00 each), this year's crop, and as an extra will send you $2.00 in U. S. currency, making the dozen apples cost you only $3.00.

When you receive the apples you can stand in front of a mirror and bite into one of them and see in the mirror an expression something like the one on my face upon receipt of your wonderful offer. You are welcome.

W. W. Stuart
Des Moines, Iowa

Mr. Stuart also tells us that he reads ICS "from the beginning."

Editor, I&CS:

You have no doubt been informed time after time that your excellent publication *Instruments and Control Systems* is one of the most informative and comprehensive technical publications in the instrumentation field. Your coverage of specific areas in each monthly issue has become a necessary part of my instrumentation file. I sincerely hope that your publication continues to prosper, enabling you to publish the articles that cannot be found in the best of handbooks or textbooks. Instrumentation has become a reality in all phases of industry, and you should feel proud that your contributions, effort and time will be remembered by many of us acquainted with your publication.

I have a five year subscription.

Carl Krisco, Project Engr.
Vapor Heating Corp.
Chicago 48, Ill.

→ HELP ! ! ←
Reader Inquiries begin on page 972

TIME FOR YOU

TO DESIGN YOUR OWN TIMING SYSTEM WITH EECO'S DO-IT-YOURSELF COMPONENTS

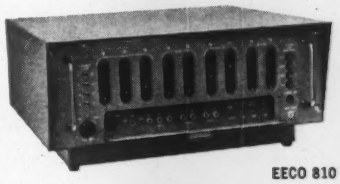
Now instrumentation engineers and test range management can build up their own precision timing systems with the convenience and economy of standardized, compatible, *all solid state,* off-shelf components. All standard time code formats available. Frequency stability, 3 parts in 10^8/day. Every EECO product is realistically priced for tight budgets. Prices include system design consultation by the leading developers of timing and synchronization instrumentation.

TIME CODE GENERATORS

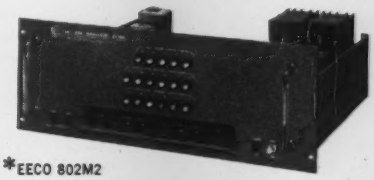
	Model Number	Serial Code Format	Time Indication	Code Frame Length (SEC)	Code Scan Rates (PPS)	Code Carrier Frequency (CPS)	Auxiliary Pulse Rates (PPS)	Price (f.o.b. Santa Ana)
	EECO 801	24-Bit, 24-hour, BCD	hours, minutes, seconds	1	25, 50, 100	1000	100K, 10K, 1K, 100, 50, 25, 10, 1	$7500
	EECO 802 (Eglin AFB and Patrick AFB)	17-Bit, 24-hour, Binary	hours, minutes, seconds	1	20, 100	1000	100K, 10K, 1K, 100, 20, 10, 1	$7000
		13-Bit, 24-hour, Binary	hours, minutes, ⅛ minutes	15	1	1000		
*	EECO 802M2 (Atlantic Missile Range)	17-Bit, 24-hour, Binary	hours, minutes, seconds	1	20, 100	1000	100K, 10K, 1K, 100, 20, 10, 1	$7000
				20	1			
	EECO 803	20-Bit, 24-hour, BCD	hours, minutes, seconds	1	25	250	None	$7500
	EECO 804	20-Bit, 24-hour, BCD	hours, minutes, seconds	1	25	100 (mixed with 1000)	1 1ppl0s 1ppm	$7925
	EECO 810	36-Bit, 365-day, BCD (4 extra bits available for identification data)	days, hours, minutes, seconds	1	100	1000	None	$10,100
	EECO 810M1 (IRIG Member C Format Modified)	23-Bit, 365-day, BCD (4 extra bits available for identification data)	days, hours, minutes, seconds	60	2	1000	10K, 1K, 100 10, 1, 1ppm, 1pphr	$10,100

Model Number		Price (f.o.b. Santa Ana)
EECO 860	**Neon Distribution Amplifier.** Accepts up to 3 pulse-width modulated signals from a time code generator to provide signals to drive camera neon lamps in remote sites.	$2500
EECO 861	**Relay Driver.** Accepts up to seven separate pulse trains or pulse-width modulated codes from a time code generator. Seven separate mercury-wetted relay contact closures to control external equipment.	$1200
EECO 863	**Line Driver** for transmitting 12 channels of carrier modulated timing signals over long distances.	$1975
EECO 27096	**Scanner Unit.** Accepts outputs from the EECO 802M1. Produces two 17-bit modified time-of-day codes in the format of the Atlantic Missile Range and one pulse rate output.	$5775

Compatible automatic magnetic tape search equipment is available for operation with each EECO time code generator.



EECO 810



*EECO 802M2

SEND FOR TIMING EQUIPMENT FILE 401, TAPE SEARCH FILE 201.

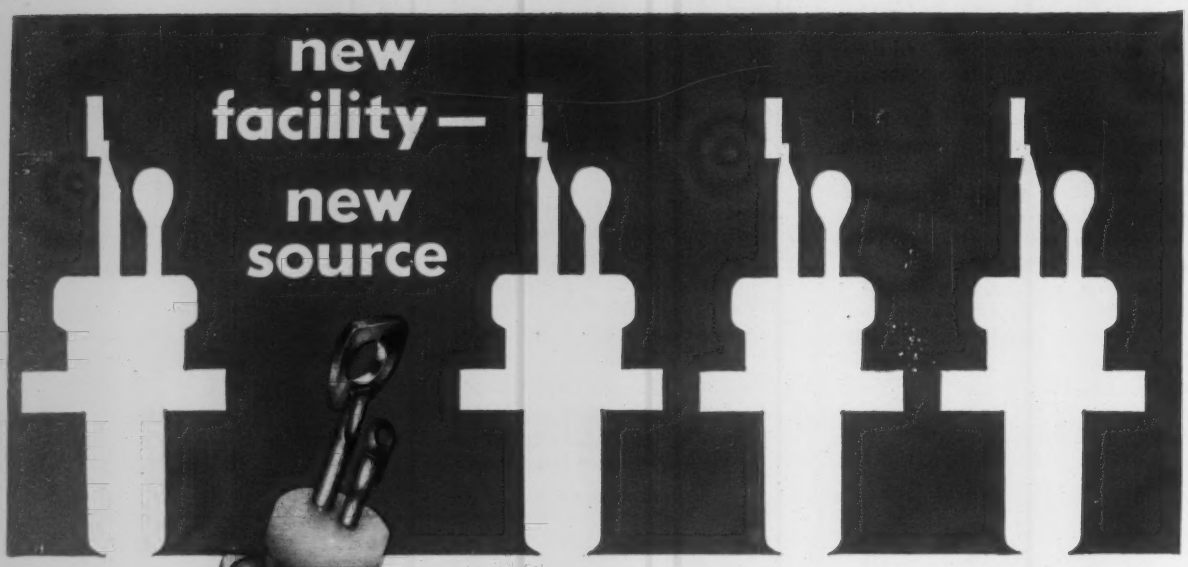
Electronic Engineering Company *of California*

1601 East Chestnut Avenue • Santa Ana, California • Kimberly 7-5501 • TWX: Santa Ana Cal 5263

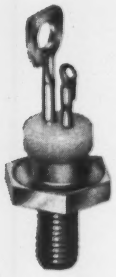
MISSILE & AIRCRAFT RANGE INSTRUMENTATION • DIGITAL DATA PROCESSING SYSTEMS • TIMING SYSTEMS • COMPUTER LANGUAGE TRANSLATORS • SPECIAL ELECTRONIC EQUIPMENT

EE 1-29

CIRCLE 10 ON READER-SERVICE CARD



SILICON CONTROLLED RECTIFIERS



Actual Size:

Tyco Semiconductor brings you a complete line of silicon controlled rectifiers designed and precision produced to meet and exceed MIL-S-19500 requirements.

You can now design with the assurance that a reliable source can deliver silicon controlled rectifiers in the 10 and 16 ampere range with each current rating available in voltage increments up to 500 volts.

Tyco silicon controlled rectifiers feature all welded hermetically sealed construction — uniform gating characteristics and low forward voltage drop. You will find the 2N1842 through 1850 and the 2N681 through 689 ideally suited for your industrial and military applications that require a reliable efficient method for the switching and control of power.

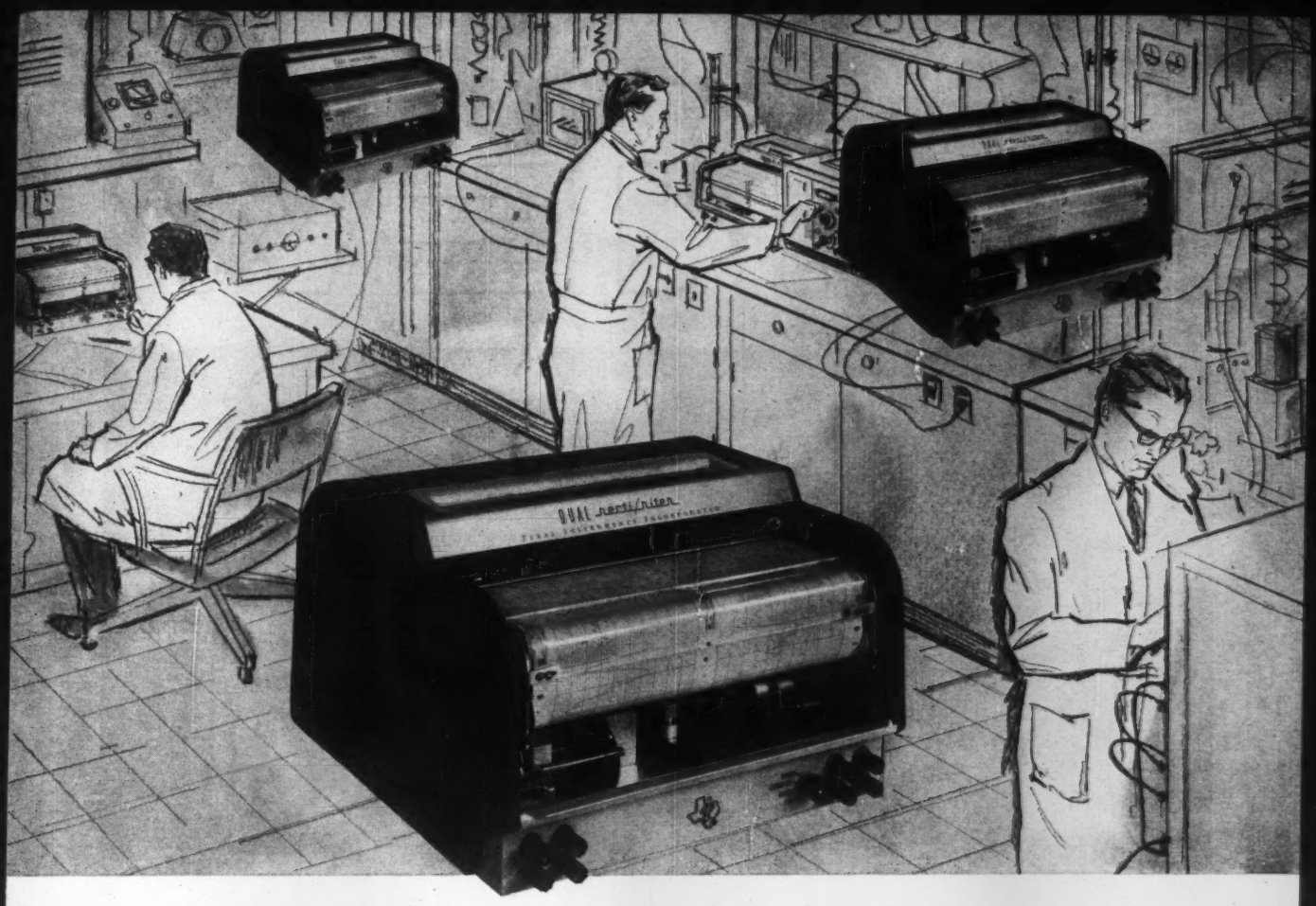
2N681 — 2N689 2N1842 — 2N1850

Type Number	PRV and V_{BO}	Max. I_{DC} @ Temp. °C	Max. Temp. °C Oper.	Stor.	Max. Req'd Gate Signal
2N681	25	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N682	50	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N683	100	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N684	150	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N685	200	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N686	250	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N687	300	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N688	400	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N689	500	25 A @ 57°C stud	125°	150°	3V, 25 ma @ 125°C T_j
2N1842	25	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1843	50	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1844	100	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1845	150	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1846	200	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1847	250	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1848	300	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1849	400	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j
2N1850	500	16 A @ 25°C stud	100°	125°	3.5V, 50 ma @ 100°C T_j

For additional information — or immediate shipment, Call or Write:

TYCO SEMICONDUCTOR
CORPORATION
BEAR HILL · WALTHAM 54 · MASSACHUSETTS
TWinbrook 9-2400

CIRCLE 11 ON READER-SERVICE CARD



operator convenience makes the recti/riter® recorder preferred for laboratory use

The *recti/riter* recorder has become the *accepted* laboratory recorder—is preferred for the exacting tasks of laboratory applications. The portable *recti/riter* is the only galvanometric rectilinear recorder designed specifically as a bench-top instrument with all routine controls and adjustments located up front for extra convenience. The "writing desk" chart carriage permits operators to make the extensive notations usually associated with laboratory use while the instrument is recording.

Ruggedized die-cast construction results in an instrument that can "take it"—yet removal of the one-piece dust cover makes every working part completely accessible and removable without further disassembly. Every *recti/riter* carries a one-year full service warranty.

There is a *recti/riter* to fit your particular requirements—single and dual channel, portable and flush-mounting models . . . each available in the widest selection of standard ranges in the industry.

Two-Cycle Pen Response

d-c Milliampere Ranges	½ ma to 100 ma
a-c Ampere Ranges	0.25 amp to 25 amp
d-c Ampere Range	100 mv for use with standard shunts
Expanded Scale a-c Voltage Ranges	80-130 V, 160-260 V, 320-520 V
a-c and d-c Voltage Ranges	10 V to 1000 V
Frequency Ranges	50, 60, 400 cps

Five-Cycle Pen Response

d-c Milliampere Ranges	2.5 ma to 125 ma

Special options and accessories further expand the versatility of *recti/riter* recorders. Write now for complete information on this *accepted* laboratory recorder line.

APPARATUS DIVISION
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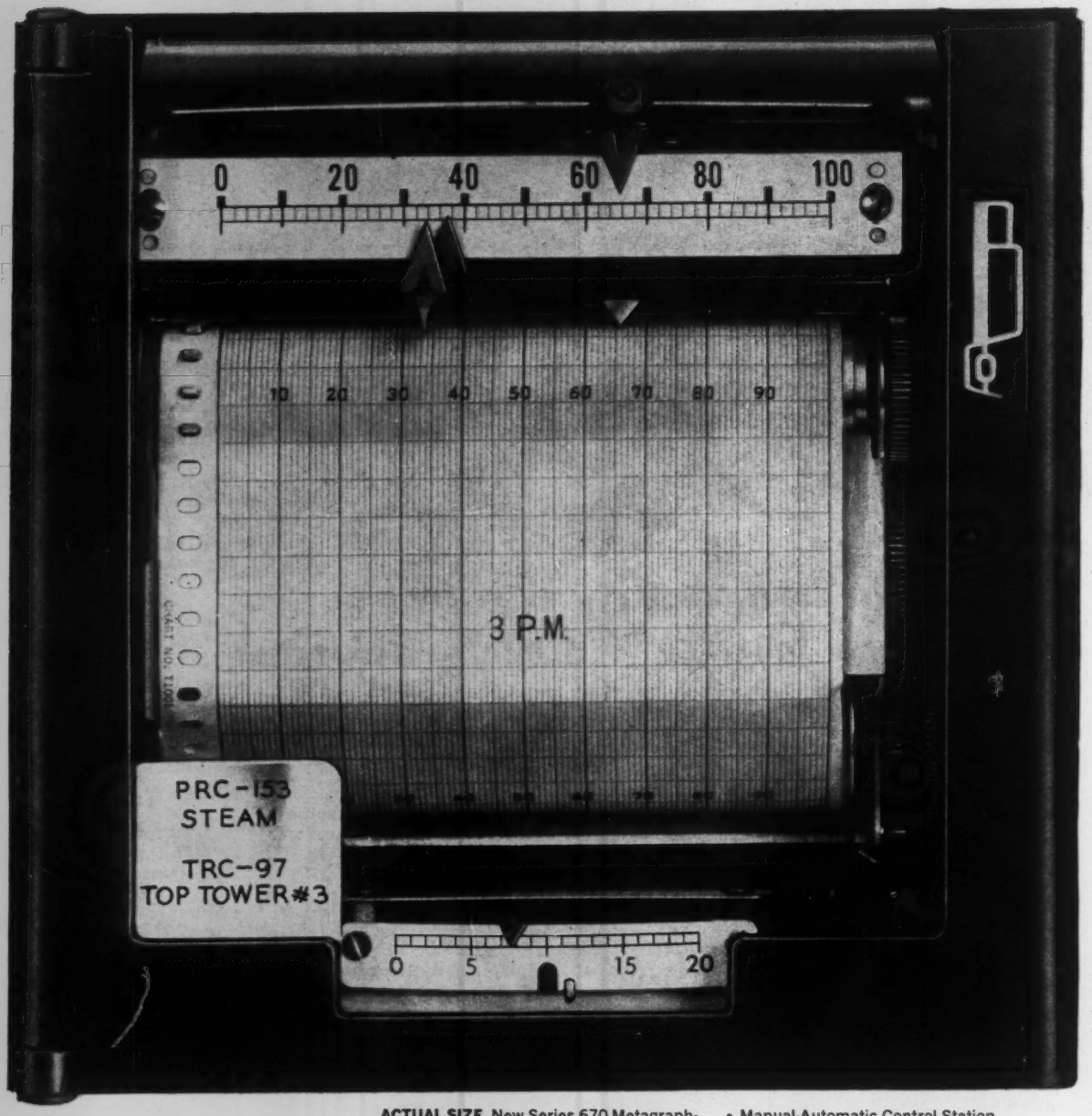
CIRCLE 12 ON READER-SERVICE CARD

NEW..



ACTUAL SIZE. New Series 670 Metagraphic is ideal for graphic panel applications, occupying panel space only 7" wide by 7⅛" high. Fits into 6" by 6" panel cutout. Typical 670 Series models available, include:

- 1-Pen, 2-Pen, or 3-Pen Receiver
- Manual-Automatic Control Station
- Manual-Cascade Control Station
- Manual-Automatic-Cascade Control Station
- Single-Case Cascade Control Station

□ here's the pneumatic receiver you asked for!

Bristol's new 4-inch-chart Metagraphic receiver

is the easiest yet to install, operate, and service

Never before has a 3-15 psi pneumatic receiver been designed with such exacting, meticulous attention to the needs of the graphic panel designer, the instrument user, and the instrument maintenance man.

Bristol's new Series 670 Metagraphic receiver brings you the plug-in versatility and operating convenience—made famous in previous Metagraphic pneumatic receivers—plus the increased legibility and accuracy of a 4-inch strip chart, plus these big new features:

Simplified control switching between functions... allows the easiest start-up procedure for either the common manual-automatic station or the more complex, single-case cascade control station models. Intermediate "seal" position has been eliminated. Just adjust process to line-up color-coded indicators and switch to automatic or cascade operation as desired.

Uniform control switching . . . all receiver models have the same switch positions for the various types of control —cascade position, 3 o'clock; manual position, 6 o'clock and automatic position at 9 o'clock.

Simplified chart change and inking . . . chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be refilled from the front of the receiver.

And the new Metagraphic receiver gives you other outstanding features such as rectilinear chart coordinates for easiest reading, easy connections for any type of control, either field or receiver-mounted controllers; and sparkless, mercury-switch disconnect of electrical circuit when chassis is removed.

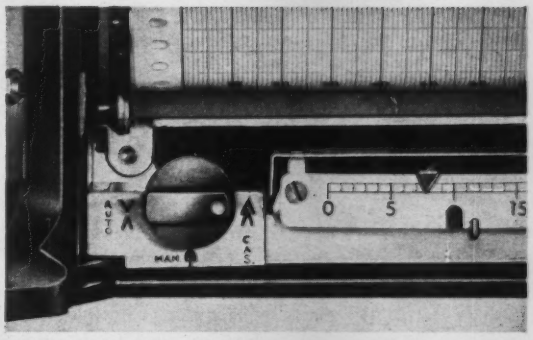
Get the complete story on the new Bristol Metagraphic receiver today. Write The Bristol Company, 113 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.42

ACCO

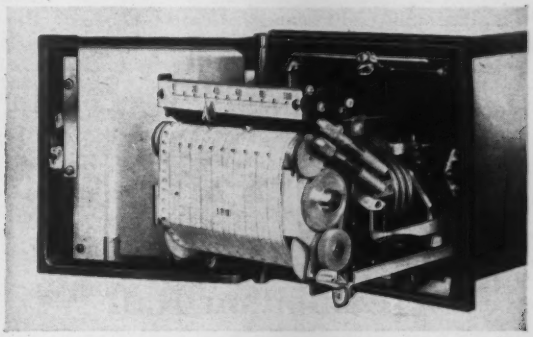
BRISTOL

...for improved production through measurement and control

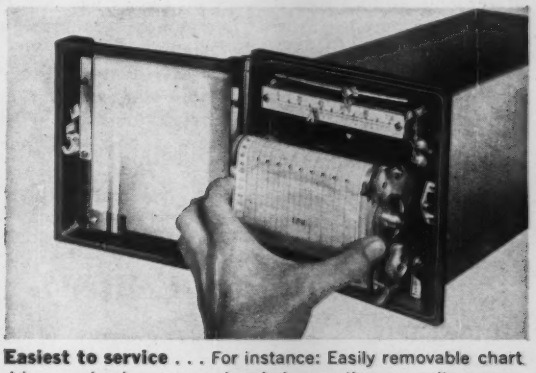
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



Simplified control switching is keynote of new receiver's design. For instance: uniform switch positions on all models avoid operator confusion in multi-receiver installations; simple alignment of color-coded pointers and a single switching operation put complex automatic or cascaded systems "on stream."



Complete "plug-in" service continuity. Entire plug-in receiver chassis is instantly replaceable with spare for complete continuity of service. Control functions are not disturbed when receiver chassis is removed.



Easiest to service . . . For instance: Easily removable chart drive mechanism—a one-handed operation—permits exceptionally fast chart replacement; just slip out drive, replace with spare, replace paper in original drive at leisure.

Come see us at the Instrument and Automation Conference and Exhibit in Toronto at Booth 206.

CIRCLE 13 ON READER-SERVICE CARD

ISA NEWS

Sixty Years NBS

WASHINGTON, D. C.—The National Bureau of Standards is celebrating its sixtieth birthday. Established in 1901 by a statute of Congress, it followed similar institutions abroad by more than a decade: Russia was first to organize its Central Chamber of Weights and Measures as early as 1878 (reorganized and enlarged in 1893), followed by the German Physikalisch-Technische Reichsanstalt (1887), and the National Physical Laboratory in England, founded in 1899.

Joint Automatic Control Conference

PITTSBURGH, PA.—The Second Joint Automatic Control Conference, this year sponsored by the ISA with the cooperation of the Denver Section; and AIChE, AIEE, ASME, and IRE participating; will be held June 28-30, 1961 at the Memorial Center of the University of Colorado in Boulder, Colo. Sixteen sessions are scheduled, dealing with such subjects as Theory of Optimization, Hydraulic and Pneumatic Control, Economic Parameters in Process Control, Optical Switching, Aerospace Vehicle Control, Process Dynamics, Automatic Control Applications, Adaptive Control Systems, Nonlinear Control Systems, Statistical Design Considerations, Process and Control Nonlinearities, and Times Series and Process Identification. Chairman of the Conference is R. K. Adams, Oak Ridge National Laboratory.

CO Monitor Guards Exhibition Hall

DETROIT, MICH.—Detroit's new $54 million exhibition building, Cobo Hall, has a 606-car underground garage, plus inside parking facilities for 400 more. A special carbon-monoxide alarm system draws samples of air from 10 locations throughout the garage area. The samples are pumped to a carbon-monoxide analyzer system (made by Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh, Pa.) The analyzer not only records the CO levels, but controls alarms and ventilation fans. A level of 100 ppm CO starts fans on one level; a level of 150 ppm starts fans on a second level; a level of 200 ppm sounds alarms.

University of Texas Computation Center

MINNEAPOLIS, MINN.—The University of Texas at Austin will soon have "one of the most powerful and flexible university-owned computer systems in the country:" The Satellite Computer System by Control Data Corporation (501 Park Ave., Minneapolis, Minn.) is actually a two-computer combination, the Control Data large-scale 1604 and the smaller desk-size Model 160.

BAUSCH & LOMB's Chairman of the Board, *Carl S. Hallauer*, has been named recipient of the 1961 SAMA award. Picture shows presentation by SAMA President, *Dr. George A. Downsbrough* (right).

WESTERN SCIENTIFIC INSTRUMENT CO. (890 Warrington Ave., Redwood City, Calif.) recently announced completion of its new headquarters, including the new "primary standards" laboratory offering electrical measurement standards certified by U. S. National Bureau of Standards.

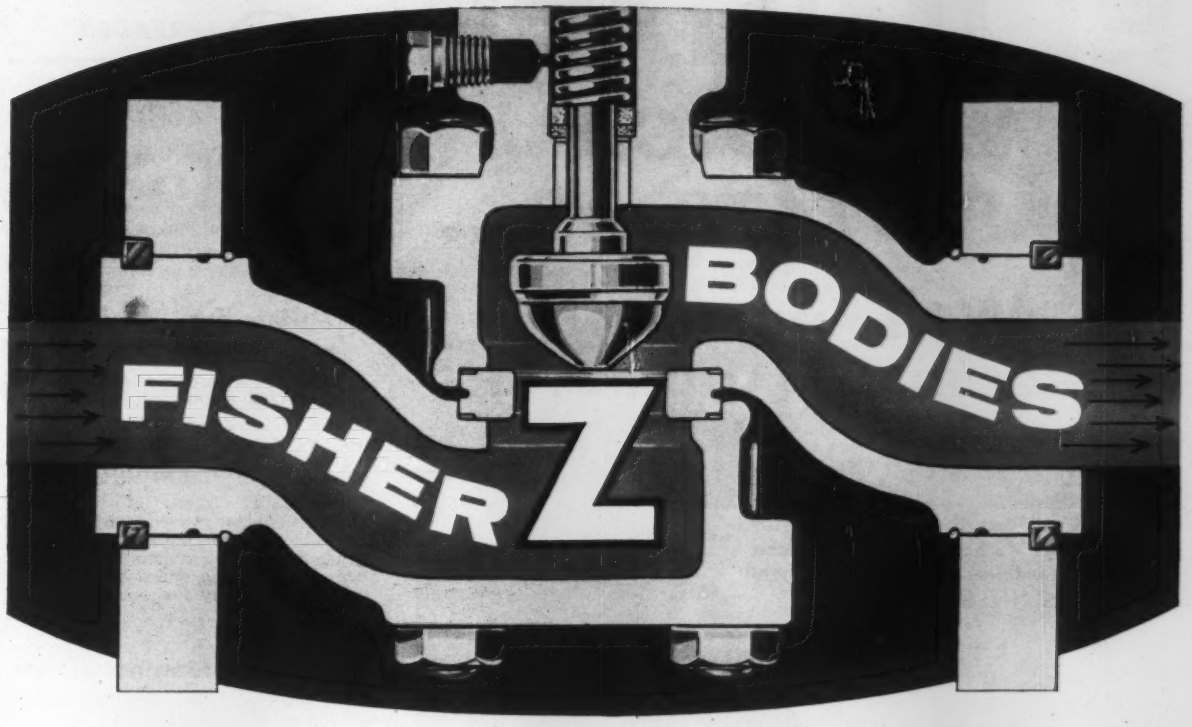
CASE INSTITUTE offers the following Special Programs: Digital Control Systems Engineering (July 31 to August 11); Automatic Optimizing and Computing Control (June 19 to 23); Process Control Theory (July 10 to 28); Analysis of Nonlinear Systems (July 10 to 21); and Operations Research (June 5 to 16, and June 19 to 30). For information write Herbert B. Schultz, Jr., Manager of Special Programs, Case Institute of Technology, University Circle, Cleveland 6, Ohio.

COMMUNICATIONS CONTROL CORP. (14707 Keswick St., Van Nuys, Calif) through its president, Dr. Martin L. Klein, recently announced a complete leasing program for its (1) Signal Sentry, an all-transistor monitor-alarm system for process control, (2) Autofax, a through-the-telephone data transmission system, and (3) high speed computers and data systems.

MIT's Special Summer Programs include a course in "Dynamics and Control of Chemical Engineering Processes," June 26 through July 7. Tuition $300.00. Address request for information to Director of the Summer Session, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

AMERICAN LABORATORIES DIVISION, American Electronics, is now operating a new acoustic test facility which permits testing of electronic components and subassemblies under actual acoustic conditions encountered in jet and rocket propelled missiles and aircraft.

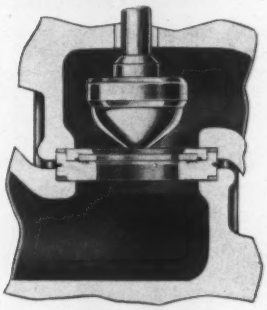
STABRO LABORATORIES of 23 Kensington Ave., Salt Lake City 15, Utah, offers a new calibration and standardization service for companies in Utah, Idaho, Nevada, Arizona, Wyoming, and Montana using electrical and electronic instruments. Laboratory instruments used are of an accuracy certified by or traceable to the National Bureau of Standards.



Can solve many of your application problems...

● Available in any castable alloy such as stainless, Hastelloy or steel ● Supplied with diaphragm or piston type actuator ● Metal seat ring is reversible ● Available in wide range of inner valve styles or orifice sizes ● "Z" body can be turned 90 degrees to reduce piping costs ● Body halves sealed with Teflon gaskets ● Flanges integral or separable ● Separable flanges permit interchanging flange ratings on a given body ● Sizes: ½" to 6". Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

TEFLON SEAT RING
Seat ring can also be supplied with Teflon insert to provide tight shut-off. This design permits using any style inner valve desired.



If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

CIRCLE 15 ON READER-SERVICE CARD

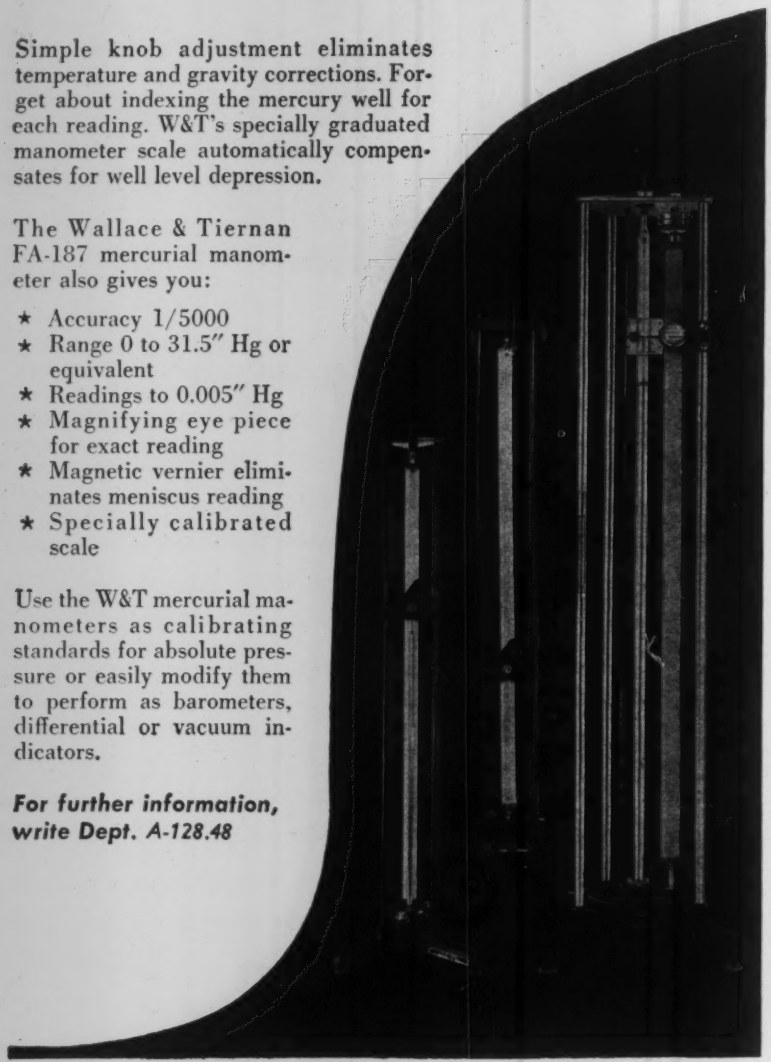
ELIMINATE
MATHEMATICAL COMPUTATIONS...

W&T PRECISION MERCURIAL MANOMETERS

Simple knob adjustment eliminates temperature and gravity corrections. Forget about indexing the mercury well for each reading. W&T's specially graduated manometer scale automatically compensates for well level depression.

The Wallace & Tiernan FA-187 mercurial manometer also gives you:

- ★ Accuracy 1/5000
- ★ Range 0 to 31.5" Hg or equivalent
- ★ Readings to 0.005" Hg
- ★ Magnifying eye piece for exact reading
- ★ Magnetic vernier eliminates meniscus reading
- ★ Specially calibrated scale



Use the W&T mercurial manometers as calibrating standards for absolute pressure or easily modify them to perform as barometers, differential or vacuum indicators.

For further information, write Dept. A-128.48

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 16 ON READER-SERVICE CARD

I&CS READER INQUIRIES

Rubber Torsion Spring

Public health engineer seeks manufacturers of "torsion springs made of an outer sleeve and a central rod, the intervening space filled with rubber." A-6129

Glass for Watches and Clocks

Manufacturer seeks suppliers of dome-shaped glass for watches and clocks. A-6130

Recorder Planimeter

Purchasing Agent of Australian electric company seeks suppliers of "integrators for automatically integrating the area under curves being drawn by a high speed pen recorder with a frequency response up to 500 cps." A-6131

Negative Ionization of Air

Director of University Department of Psychology seeks "instrument for the estimation of negative ionization of air particles, usually done by air-sampling electrometer device." A-6132

Temperature Control for Textile Finishing

Manufacturers' representative seeks inexpensive device to control calander temperature in textile finishing process (other than sliding ribbon thermocouple or infrared). A-6133

Can You Help These Medical Men With Their Problems?

Ozone Concentration

Technical director of research lab in V. A. hospital desires information on alarms set off by lower limit of ozone concentration in atmosphere. M-11

Hemoglobin Concentration

Medical doctor with private practice desires information on techniques measuring hemoglobin concentration in full blood, other than Sahli technique. M-12

Log of Electrical Signal

Instructor in pathological department of university school of medicine wants to obtain log of electrical input signal of 0-to-30-kc bandwidth over 100:1 range with maximum signal in the order of 10 v. M-70

GSR, Blood Pressure

Physician of industrial firm wishes to obtain information on measuring GSR, blood pressure in monitoring console operators. M-13

Pressure Indicator

Associate university professor of medicine needs apparatus to measure pressure in mixture freezing living cells in suspension. Preferred indication in kg/mm² units. M-14

Physics of Blood Flow

Instructor in surgery at university medical center needs manometer which works at end of ½-mm diameter intravascular catheter; also flowmeter (absolute and phasic) for physics of blood flow in patients, the laboratory, and practical use in O.R. Manometer range to be 0 to 300 mm Hg; flowmeter range, 0 to 10 lit/min, both dc to 200 cps. M-15

Blood Urea Nitrogen

Biochemist in aero-medical company seeks technique (other than urease powder) to measure micro blood urea nitrogen samples of less than 0.5cc before and after stress of subject. M-16

Particulate Matter in Parenteral Solutions

Research manager of rubber company wishes to measure particulate (foreign) matter in packaging of parenteral solutions. M-17

C^{14} O_2 Flow

Professor of physiology at university school of medicine wishes to measure C^{14} O_2 constant flow from rat in metabolism of labeled fat. Present method used is collecting BaC^{14} O_3. M-18

Blood Flow

Professor of physiology at university school of medicine seeks methods of measuring blood flow for research. M-19

Venous and Arterial Blood Flow

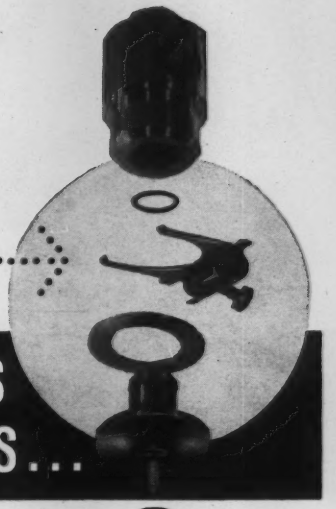
Assistant director of professional services for research in V. A. hospital wishes to measure blood flow in intact veins and arteries without isolation of the vessel. M-20

Blood Flow

Electrical engineer at university medical school is interested in blood flow measurement. M-21

(*Cont. on page* 1139)

With this new Varea-meter external clamp



NOTHING UNSEATS ROTAMETER TUBES...

One big benefit you get from Wallace & Tiernan's new Varea-meter line is dependable tube clamping. Tubes can't vibrate loose; can't be dislodged, even by sudden flow surges.

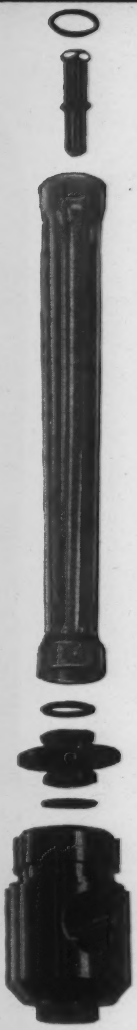
A simple but effective lever-type clamp gives a positive tube-locking force.

But for all its holding power, this force is easily controlled. You release tubes by loosening a single bolt . . . change capacities or remove tubes for cleaning in seconds.

There is no packing; O-rings give positive sealing. There are no springs; the tube is locked by the lever-type clamp. Because this clamp applies force externally, there is nothing in the flow path to clog your meter or corrode.

Teflon or Penton O-rings and tube adapters, and a wide choice of end-fitting materials, allow you to measure highly corrosive chemicals.

W&T Varea-meters come in ⅜" to 3" tube sizes with 5" or 10" scales. Electric or pneumatic transmitters and other accessories are available. Varea-meters conform to ISA Recommended Practice.



For more information, write Dept. V-4.48

WALLACE & TIERNAN INC.

28 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 17 ON READER-SERVICE CARD

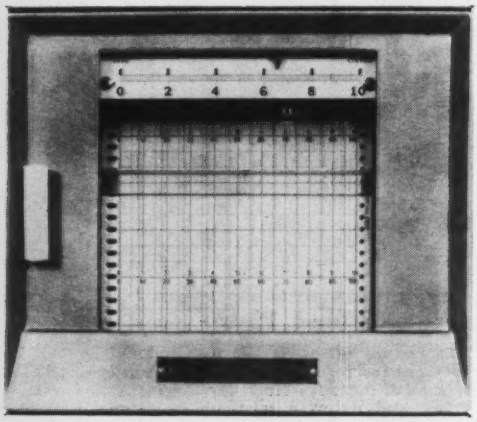
if PANEL SPACE or PORTABILITY is your problem...

The Westronics Miniature MULTIPOINT Recorder Model M5A is your perfect solution.

The panel space occupied by the Westronics Miniature MULTIPOINT Recorder is only 8½ x 9⅝ inches, or only 25% of the panel space required by most large case recorders.

The Westronics Miniature MULTIPOINT Recorder scans and measures 2 to 12 different input sources at the rate of 5 seconds per point.

Westronics manufactures a complete line of miniature and full size recorders with more optional features than any other manufacturer.



STANDARD UNITS AVAILABLE FROM STOCK. SPECIFICATIONS UPON REQUEST.

wi westronics, inc.

TWX FT 8248 U • 3605 McCART STREET • FORT WORTH, TEXAS

CIRCLE 18 ON READER-SERVICE CARD

CIRCLE 19 ON READER-SERVICE CARD ⟶

The LGP-30 Electronic Computer begins breaking up figure-work bottlenecks the very same day it is delivered.

The Royal Precision LGP-30 is a complete electronic computer system that is delivered to you ready to go to work. It requires no special personnel. It is simple to program and operate . . . an engineer can use it himself. It requires no air-conditioning or expensive site preparation. In fact, it requires *no* site preparation. Just roll the LGP-30 to where it's needed and plug into the nearest convenient 110-volt AC wall outlet. It's mobile, so it goes anywhere . . . desk-size, so it takes little room.

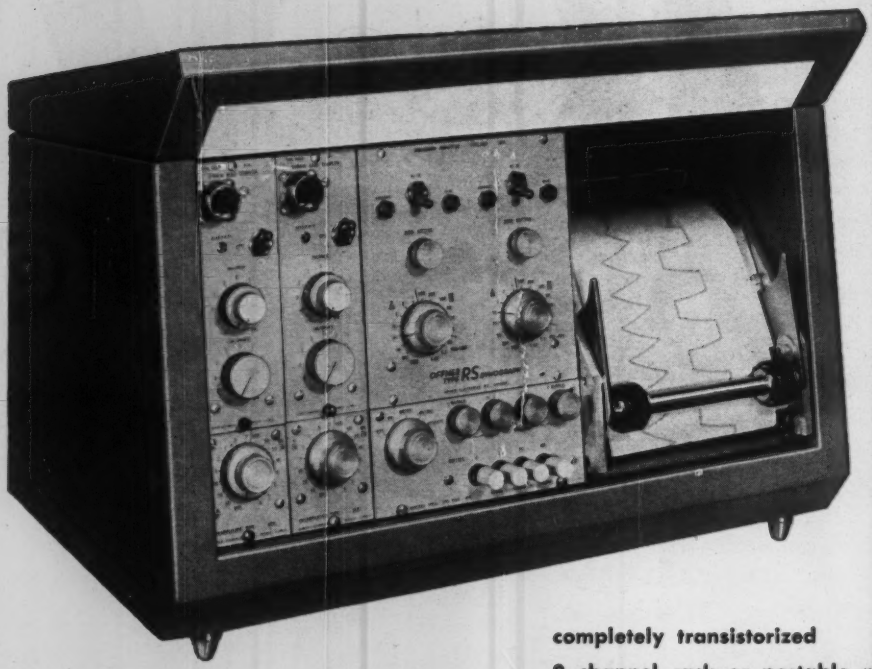
And, though the LGP-30 can solve routine and theoretical math problems 30x faster than any man—it rents for little more than the salary of an additional engineer. Amazing? No, just well-designed, *advanced*. Let us tell you more about it. Write: Mr. Floyd Ritchie, Royal McBee Corporation, Port Chester, New York.

ROYAL McBEE | GENERAL PRECISION

ELECTRONIC DATA PROCESSING SYSTEMS

OFFNER

TYPE RS DYNOGRAPH



completely transistorized
2 channel rack or portable mounting
unmatched accuracy and versatility

25 years ago Offner invented the world's first Direct-Writing Oscillograph.

Microvolt sensitivity, unmatched accuracy and compact design are combined with exceptional versatility in this completely new two channel Type RS Dynograph.

All-transistorized, table or rack mounted, conveniently carried for portable use, the Type RS Dynograph provides the same exceptional performance specifications as the Offner Type R Dynograph. Write for complete details.

Sensitivity: With preamplifiers, 10 microvolts per cm to 50 volts per cm.

Warm-up: Instantaneous.

Drift: One microvolt per hour pen drift at maximum sensitivity.

Ambient Temperature Range: —20° to +60° C.

Frequency Response: Within 10% to 150 cps, and 20% to beyond 200 cps.

Recording Media: Rectilinear Heat or Electric, Curvilinear ink or electric, easily converted.

Deflection Time: 2.5 MS with preamplifiers, 1.5 MS without.

OFFNER ELECTRONICS INC.

3910 River Road, Schiller Park, Ill.
(Suburb of Chicago)

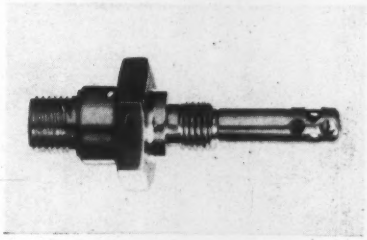
CIRCLE 20 ON READER-SERVICE CARD

AIRBORNE DC AMPLIFIER

Small, solid state, direct-coupled DC amplifier weighs only six ounces. Less than five cubic inches in volume, this rugged, hermetically sealed instrument is available with solder, plug-in, coax or combination header arrangements and a variety of mountings. DC gain is 200 to 1000 ±0.75%. Input capability is 5 millivolts differential at maximum gain; output capability is ±5 volts into not less than 20K (single-ended). Companion power supply also available.—*Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.*

CIRCLE 33 ON READER-SERVICE CARD

TEMPERATURE TRANSDUCER

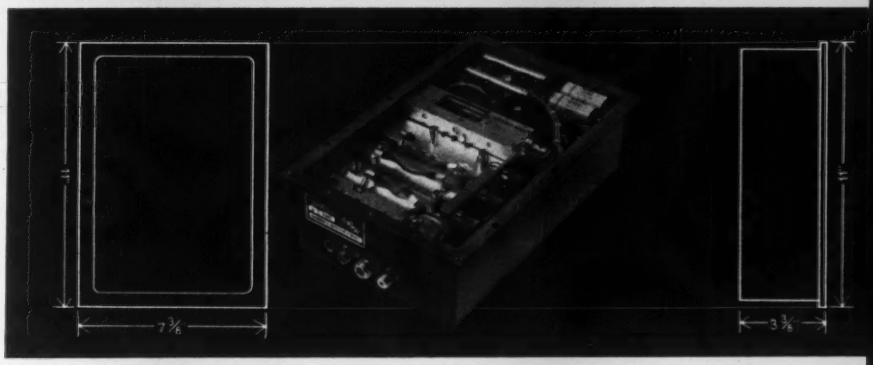


Small probe-type device for high and low temperature applications where high pressures and severe flow conditions are imposed. Precise liquid or gaseous measurements to 800°F. Tiny sensing element of deposited platinum film allows high base resistance, extreme linearity, wide range capability, and fast response. Approved for ICBM environments.—*Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.*

CIRCLE 34 ON READER-SERVICE CARD

CIRCLE 35 ON READER-SERVICE CARD →

VHF-UHF TRANSMITTERS



Proved in history's most demanding environmental laboratory — outer space — the custom designed unit shown above is typical of the development skill and production capability available from Microdot. The unit shown in miniaturized, pressurized, and features a solid state power supply that cannot be damaged by input/output overloads. Units are available in a complete range of modulation — CW, FM, Phase, and Pulse, with frequency coverage 100 to 5000 mc/s and output from 100 mw to 10 watts.

Telemetry Capabilities at Microdot have been dramatically expanded with the recent acquisition of Spectralab Instrument Company. The highly regarded development skill, production capability, and working experience of Spectralab in the field of VHF and UHF cavities and related instrumentation is available from Microdot's Instrumentation Division. This equipment, outstanding in its attention to miniaturization and ruggedness, is a vital part of such important projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone and Echo I.

UHF Telemetry Transmitters, Models 2406 and 2409, use a unique, automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. This approach allows a greatly reduced size compared to the multiplier chain conventionally required to achieve crystal stability, as well as increased reliability due to a fewer number of parts.

The transmitters have their own solid state power supply designed to provide a high ratio of rf output power to total power input. The frequency modulation circuitry is sufficiently linear to introduce completely negligible distortion to the modulation signal. For further information, Call Microdot or write for catalog sheet TT-1.

SPECIFICATIONS	
Frequency Range:	
Model 2406	2200-2300 mc/s
Model 2409	1435-1535 mc/s
Frequency Stability:	± 0.001%
Power Output:	10 watts
Power Output Stability:	1 db
Modulation:	PCM/FM, PAM/FM, FM/FM
Input Voltage:	28 vdc
Temperature Range:	-40°C to +70°C
Vibration:	10 g, 5-2000 cps
Size:	3½" x 7⅛" x 11"
Weight:	12 pounds

MICRODOT INC.

220 Pasadena Avenue, South Pasadena, Calif.

MUrray 2 3351 SYcamore 9 9171

What's YOUR Portable Power Problem?...

BURGESS has more than 5000 battery types to choose from:

ZINC-CARBON
MERCURY
NICKEL-CADMIUM
WATER-ACTIVATED

each with the highest measure of uniform dependability! This is why 2 of 3 electronic engineers specify

BURGESS BATTERIES

The Most Complete One-Source Line of PORTABLE POWER!

ZINC-CARBON

Most popular source of portable power, zinc-carbon batteries excel in adaptability, availability and economy. Burgess offers the widest range of choice in cylindrical and flat cells, plus exclusive patented "wafer-cell" construction for more compact power and uniform performance.

MERCURY ACTIVATORS

Burgess Quality-Controlled mercury batteries assure uniform operation over wide temperature range, high ampere-hour output, flat discharge curve. Long, non-fading service for instruments, transistor radios, portable electronic products.

SEALED NICKEL-CADMIUM BATTERIES

A secondary rechargeable battery system which delivers high energy output from a small package! Hermetically sealed-in-steel cells eliminate maintenance and addition of liquids. Can be recharged many times, by trickle or quick charge, for long lasting economical power!

RESERVE BATTERIES

High energy output in a compact power source. Can be stored dry for years! Activated only when immersed in water. No handling of dangerous electrolyte, no spilling or leaking! Wide range of efficient operating temperatures. Designed for your specific applications.

EXCLUSIVE WAFER-CELL

This construction offers compactness, long shelf life, exceptional service life. A 30% increase in battery life at no increase in size.

Check with your Burgess Distributor for complete local stocks of fresh BURGESS BATTERIES! Or your distributor can order from Burgess the special battery needed for your specific application!

FREE DESIGN SERVICE

For special applications, skilled Burgess Engineers offer you a FREE battery design service. Burgess will manufacture the exact battery to fit your needs, regardless of quantity required.

NEW ENGINEERING MANUAL

New 100-page dry battery handbook now available! Engineers engaged in the design of battery-powered equipment are invited to write to Burgess Battery Company, Dept. ED, Freeport, Ill., to secure a copy. Others may buy the manual for $1.00.

BURGESS BATTERY COMPANY
Division of Servel, Inc.
FREEPORT, ILLINOIS

CIRCLE 21 ON READER-SERVICE CARD

ICS STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1961 THRU MAY 17, 1961

	High	Low	Price As Of 5/17/61
ACF Industries	58 7/8	38	58 7/8
Aeroquip Corp.	36 5/8	22 1/4	33
Allis Chalmers	29 1/2	23 3/8	29 1/8
American Chain & Calbe	51	42 7/8	51
Amer. Mach. & Foundry (new)	63 5/8	51 1/2	56
Amer. Mach. & Metals	48	34 1/8	48
American Meter	53 3/4	43	51 1/8
American Optical	89	54	67 5/8
American Tel. & Tel.	130	103 1/8	126 7/8
Ampex Corp.	27 3/4	20 1/4	24 3/4
Aro Equipment	35 1/2	20 1/8	34 3/8
Bausch & Lomb Optical	46 5/8	38 1/4	41
Beckman Instruments	145 3/4	87	143
Bell & Howell	68 7/8	48 3/4	64
Bendix Aviation	72	61 1/4	64 1/2
Boeing Airplane	48 1/4	35 1/2	46 1/4
Bullard	19	11 1/4	19
Bulova Watch	22 1/4	15 7/8	19 7/8
Burroughs	38 1/4	27 1/2	33 3/4
Carborundum	60 1/4	44 1/4	59 3/4
Cinn. Milling Machine	49 1/4	37 1/2	46
Clevite	70	47 3/4	70
Columbia Broadcasting Sys.	42 3/8	35 3/8	40
Consol. Electronics	46 1/2	36 1/8	40 5/8
Corning Glass	194 3/4	167	179 1/2
Curtiss Wright	22	15 5/8	20 3/8
Cutler-Hammer	75 1/2	62 3/8	75 1/2
Daystrom	34 3/4	25 3/8	27 3/4
Douglas Aircraft	38 1/2	28	33 1/8
Eastman Kodak	119 3/4	104 1/4	114 7/8
Eaton Mfg.	38	30 3/8	35 1/4
Electric Auto-Lite	67 3/4	44 5/8	63 1/2
Elgin Watch	16 7/8	11 3/4	15 1/2
Emerson Electric	87 1/2	50	85 7/8
Engelhard Industries	33 7/8	18 1/2	31 1/2
Food Mach. & Chem.	76 1/2	59 1/8	75
Foxboro Co.	87	72 1/2	70 1/2
Garrett	56 3/8	46 3/8	53 5/8
General Controls	22 1/2	17 1/8	19 3/8
General Dynamics	45 1/2	36 5/8	37 3/4
General Electric	74	60 1/2	67 1/4
General Instruments	55 1/2	37 5/8	50 7/8
General Mills	37	31	32 3/4
Gen. Precision Equip.	75 5/8	54 1/2	75 1/4
Gen. Railway Signal	54 3/4	29	50 1/2
Gen. Tel. & Elect.	32 1/2	26 1/2	28
General Time	20 3/8	14 1/4	18 3/4
General Tire & Rubber	76 3/8	53 3/4	73 1/2
Hewlett-Packard	53	36 3/4	40 1/4
International Bus. Mach.	479 1/4	450	455
International Resistance	42 1/8	26	37 1/8
Internat'l. Tel. & Tel.	60 7/8	44 3/4	57 5/8
Lear Inc.	29 3/8	16	26
I-T-E Circuit Breaker	24 5/8	18	20 7/8
Litton Industries	143	87 1/8	129 1/8
Lockheed Aircraft	45 5/8	26 1/2	42
Magnovox	95 3/4	46	94
Mallory	60	36 5/8	55
Manning, Maxwell & Moore	27 3/8	21 7/8	27 1/2
Minneapolis-Honeywell	170 3/4	140	149 1/2
Minnesota Mining & Mfg.	87	70 1/8	82 1/4
Motorola	100	75 1/8	95
National Acme	59 1/2	47	57 1/2
National Cash Register	104 1/2	61 7/8	99 1/8
Neptune Meter	29 1/2	22 7/8	27
North American Aviation	53 5/8	41 5/8	48 1/2
Northrop Aircraft	67 3/8	41 1/2	63
Otis Elevator	79	56 1/2	68 1/4
Philco Corp.	25 1/8	17 3/4	23 1/4
Radio Corp. of Amer.	65 5/8	49 1/2	63 7/8
Raytheon Mfg.	42 7/8	35 1/4	39 1/2
Reliance Electric	67	47 1/2	66
Rheem Mfg.	23 1/2	13 1/2	20 1/4
Robertshaw Fulton	44 1/2	32 7/8	44 1/8
Royal McBee	19 3/8	13 1/4	16 7/8
Sangamo Electric	22	14 3/8	21
Siegler Corp.	34	27	30 3/8
Sperry Rand	35	20 1/2	32 3/4
Square D	41 3/4	29 5/8	41 3/8
Standard Kollsman	53	25 1/8	49 3/4
Starrett (L.S.)	22	17 3/4	20
Stewart-Warner	28 5/8	24 3/4	28 1/2
Telautograph	20 7/8	12 5/8	18 1/4
Texas Instruments	206 3/4	165 3/4	198 1/2
Thompson-Ramo-Wooldridge	82 3/8	67 3/4	74
Tung-Sol Electric	33 1/4	25 3/8	31 1/2
Underwood Corp.	65 1/2	42 1/2	63 1/8
Union Carbide Corp.	140 3/8	116	142
United Shoe Machinery	76 1/4	54 5/8	73
Varian Associates	77 3/8	46 5/8	66 1/2
Wallace & Tiernan (new) (a)	41 1/2	26 1/2	39 1/4
Western Union	55	39 3/4	47 3/8
Westinghouse Air Brake	28 1/8	22	28 1/8
Westinghouse Electric	50	40	44 3/8
Worthington Corp.	66 1/2	49	65 3/4

These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1961 THRU MAY 17, 1961

	High	Low	Price As Of 5/17/61
Barry Wright	29 3/4	15	23 1/2
Belock Instruments	20 1/4	14 5/8	19
Benrus Watch	11 1/2	6	10 1/4
Breeze Corp.	9 1/4	4 1/8	9
Burnell & Co.	17	6 1/2	15
Clark Controller	21 1/4	16 1/2	18 5/8
Clarostat Mfg.	20	12	15
Clary Corp.	22 3/8	8 5/8	17 3/4
Cubic Corp.	106	51 1/2	92
Dynamics Corp. of Amer.	20 1/4	7 5/8	16 3/8

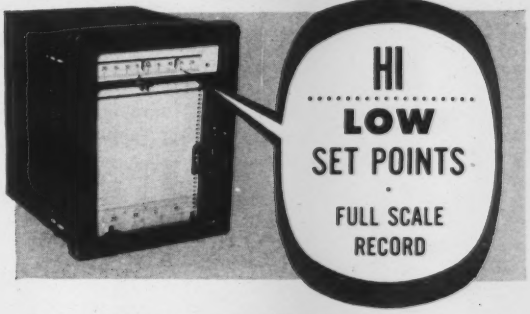
El-Tronics	9 3/4	5	7 1/2
Electronics Corp. of Amer.	14 1/2	9	13 3/4
Fairchild Camera & Instruments	195 1/2	130	184
Fischer & Porter Co.	31 7/8	16	28 5/8
Giannini Controls	82 1/4	52	73 1/2
Globe Union	35 1/2	23 1/2	34 5/8
Haseltine Corp.	47 7/8	25 1/2	43 7/8
Loral-Electronics (new) (a)	46 1/4	31 5/8	42 1/8
National Research	31 7/8	17 5/8	26 5/8
New Haven Clock	2 1/2	1 1/8	2 1/2
Nuclear Corp. of Amer.	8 1/4	3 7/8	7
Philips Electronics, Inc.	39 1/2	31 1/4	34 3/8
Pneumatic Scale	50	39 1/2	44 1/2
Polarad Electronics	28 3/8	18 3/4	25 3/4
Servo Corp. of Amer.	19	11 1/4	14 3/8
Servomechanisms	13 1/4	7 3/4	12 1/8
Statham Instruments Inc.	35 3/8	26	29 3/4
Textron Electronics	14 3/8	9 3/8	10
Victoreen Instrument Co.	19 1/4	13 1/8	17 1/4
Waltham Prec. Instr. Co.	4 7/8	1 3/4	4

These prices and price ranges are given as printed in the Wall Street Journal.

OVER THE COUNTER

	Quotation As Of May 17, 1961	
	Bid	Asked
Aerovox Corp.	12 1/2	13 7/8
Argus Corp.	40 1/4	40 1/2
Black Sivalls & Bryson Inc.	14 3/4	16
Computer Systems	30	32
Eitel McCullough	18 7/8	19 3/8
Electro Instruments	22 1/2	24 1/2
Electronics Associates	34 3/4	37 1/2
Erie Resistor Corporation	14 1/2	15 3/4
Fisher Governor Co.	26 3/8	28
Hagan Chemicals & Controls	61	65 1/2
Milgo Electronic Corp.	25 1/2	27 3/4
Industro Transitor	5	6
Liquidometer Corp.	17	18
W. L. Maxson	29	31 1/8
Penn Controls	23 3/4	24 3/4
Speer Carbon, Inc.	23	25 1/8
Sprague Electric	75	78 3/4
Taylor Instruments (new)	52 1/2	56 1/2
Telechrome Mfg. Corp.	15 5/8	16 7/8
Telecomputing Corp.	8 1/8	8 3/4
Vitro Corp. of Amer.	32 3/4	35 1/8
Wallson Associates Inc.	7	7 3/4

Now Available With Curtiss-Wright Rectilinear Strip Chart Recorders



For Maximum-Minimum Control

Built-in HI-LOW set points for maximum-minimum control are now available with Curtiss-Wright Rectilinear Strip Chart Recorders. This feature provides the means for actuating control processes and warning signals, without restricting pen movement.

The "maximum set point" adjusts to between 30-100% of full scale, and the "minimum set point", between 0-70% of full scale. Minimum separation is 7% of full scale. The completely transistorized control circuit is inductively coupled to the writing pen, eliminating mechanical interference.

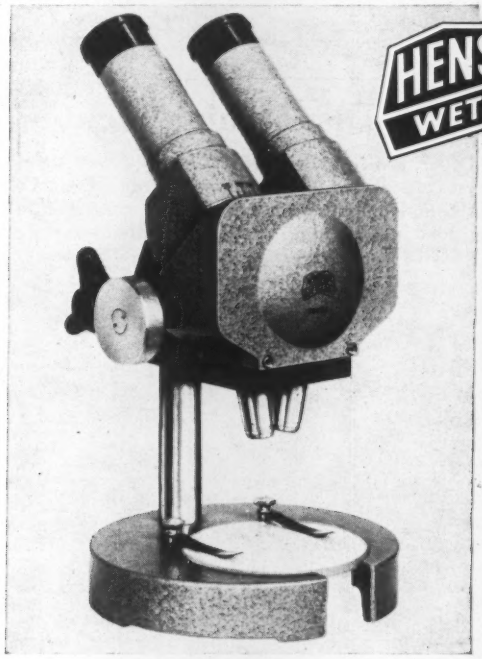
Except for the alarm-control relays, the complete set-point circuits are mounted inside the recorder. Built-in fail-safe circuits assure dependable operation — a set-point circuit failure will close the normally open alarm-control relay.

Send for catalog or phone SWinburne 9-0500.

CURTISS WRIGHT CORPORATION

Princeton Division Princeton, New Jersey

CIRCLE 22 ON READER-SERVICE CARD



HENSOLDT WETZLAR

"DIAMAL" II STEREO-MICROSCOPE

3.3x to 80x

The high optical efficiency and compactness of this fine instrument make it ideal for the shop, inspection room or the laboratory.

The parallel inclined eye-pieces afford strainless three-dimensional vision. And its range of magnifications is exceptional in a stereoscopic instrument.

Interchangeable optical systems for magnifications from 3.3x to 80x are available. Also four different types of stands suitable for transmitted or reflected light, various reflected light illuminants, etc.

HENSOLDT QUALITY

The "Diamal" II is representative of the fine optical quality for which Hensoldt of West Germany has been noted since 1852.

MADE IN WEST GERMANY

Write for detailed literature

COMPLETE SERVICE FACILITIES

CARL ZEISS, INC.

485 FIFTH AVENUE, NEW YORK 17, N. Y.

CIRCLE 23 ON READER-SERVICE CARD

NEW APPLICATIONS

ROYAL McBEE is sending four mobile, 50-foot-long "Computeramas" on a 100,000-mile-a-year tour of American cities. The two Royal Precision computers and data processors housed in the trailer will provide executive-

level demonstrations of electronic computing and data processing equipment. Discussing the Computerama with *Fortune Peter Ryan*, (right) president of Royal McBee, are *Allan A. Ryan* (center), chairman of the board, and *Carl P. Ray*, vice president of marketing.

ASSOCIATED CONTROL EQUIPMENT, INC. (Coraopolis, Pa.) installed an all-pneumatic coagulant proportioning system at the Fairless Works of U. S. Steel Corporation consisting of a proportioning metering pump controlled by a flow transmitter that measures the flow of untreated water into a flash mixer.

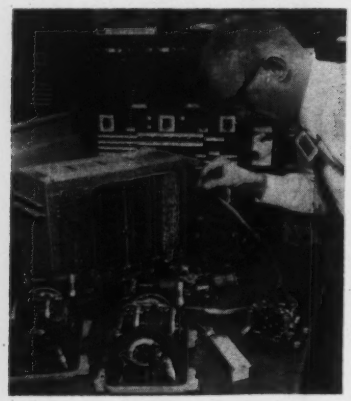
The automatic system has resulted in increased effectiveness and efficiency of water treatment and savings in labor.

PACKARD BELL COMPUTER CORP. (1905 Armacost Ave., Los Angeles 25, Calif.) reports exceptional performance of the first PB 250 digital computer delivered to the Bailey Meter Co. for use in an automatic control system for electric power generation. It has performed in continuous operations without interruption or error for more than 1600 hours.

ELECTRONIC ASSOCIATES, INC. (Long Branch, N. J.) delivered a $1.510.000 computer to NASA. It contains more than 1,500 high-speed computing units, including 800 specially designed amplifiers. Complex mathematical equations can be solved in less than a minute's time after the problem has been programmed into the computer. Also supplied were three Automatic Digital Input-Output Systems (ADIOS), each able to set up any part of or the whole system from previously prepared punched paper tape or manual keyboard.

At the invitation of the Japanese National Committee of Automatic Control, nine automatic control scientists from American Universities and industry toured laboratories, plants, and universities in Japan, May 9 to 30. Professor **RUFUS OLDENBURGER,** director of the Automatic Control Center in the School of Mechanical Engineering at Purdue University was chairman of the team.

MINNEAPOLIS-HONEYWELL built the automatic pilot, including five gyroscopes, a tiny accelerometer, and



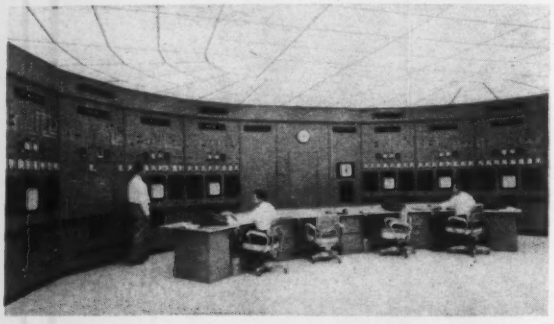
a computer, which played an important role in Project Mercury, which sent the first U. S. astronaut into space and returned him safely to earth.

WESTON INSTRUMENTS DIV. of Daystrom (229 Manchester Rd., Poughkeepsie, N. Y.) has furnished the XactRAY X-Ray gauge which scans Transite asbestos-cement pipe at Johns-Manville for variations in wall density.

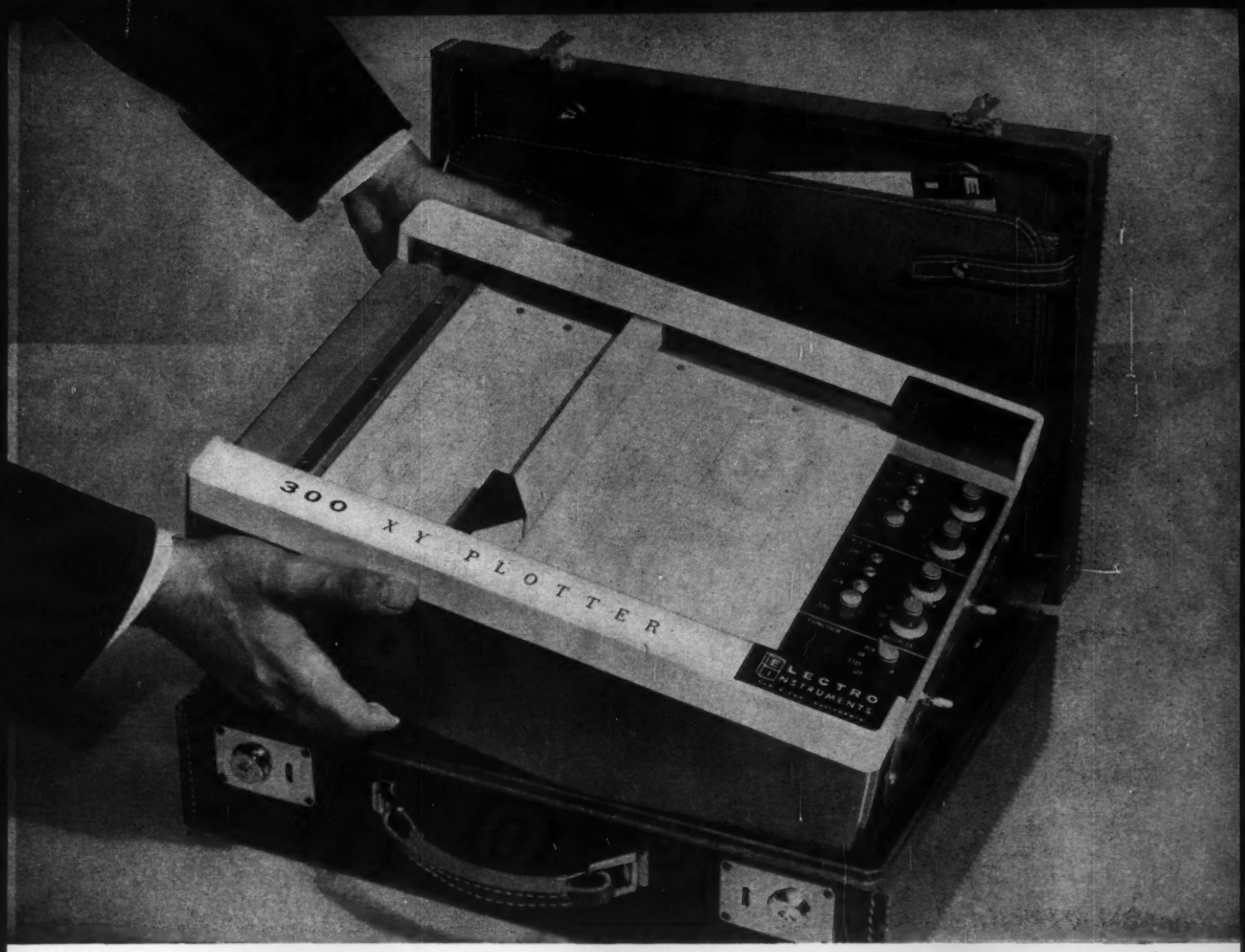
ALLIS-CHALMERS, CONSOLIDATED SYSTEMS CORP., (jointly owned by Consolidated Electrodynamics and Allis-Chalmers) and **IBM** have concluded an agreement of mutual support in the engineering and marketing of automated control systems and processes.

Gas Load Dispatching Center

NEWARK, N. J.—New Brunswick General Sheet Metal Works, Highland Park, N. J., manufacturer of Genco panels has completed the paneling for the new million dollar gas load dispatching center of Public Service Electric and Gas Company in Jersey City. The center



contains 28 individual telemetering panels, totaling 138 ft in length, in the form of an ellipse. Presently, ten of the panels, each of which is connected by a leased telephone circuit to a separate outlying natural gas metering station, are in operation. The monitoring and control of pressures and natural gas flows, in the metering stations and remote sections of the gas distributions system, are controlled at the gas dispatching center through the use of tone telemetering transmitted over telephone wires.



NEW!
the world's first totally-transistorized 8½"x11" x-y recorder

...easily fits into an attache case, almost as portable! Numerous mechanical and electrical design advances have been incorporated into this completely new EI recorder. Besides greater reliability and low power dissipation resulting from its all-transistorized design, the Model 300 provides faster slewing speeds, improved accuracies, additional scales and ranges and other performance features to widen its application. The distinctive, modern cabinet design is "human engineered," with operating controls and inputs conveniently grouped at one end for maximum operator convenience. All electronic circuitry is contained in a single assembly that can be removed in seconds. Without a doubt, the new Model 300 is the most advanced 8½"x11" X-Y recorder available today, developed and *proved by more than 5 years' experience*. Let your EI Field Engineer demonstrate this exciting new recorder to you. Through a nationwide staff of factory sales and service men you are assured the most for your money—before, during and after the sale. *Write today for new x-y catalog!*

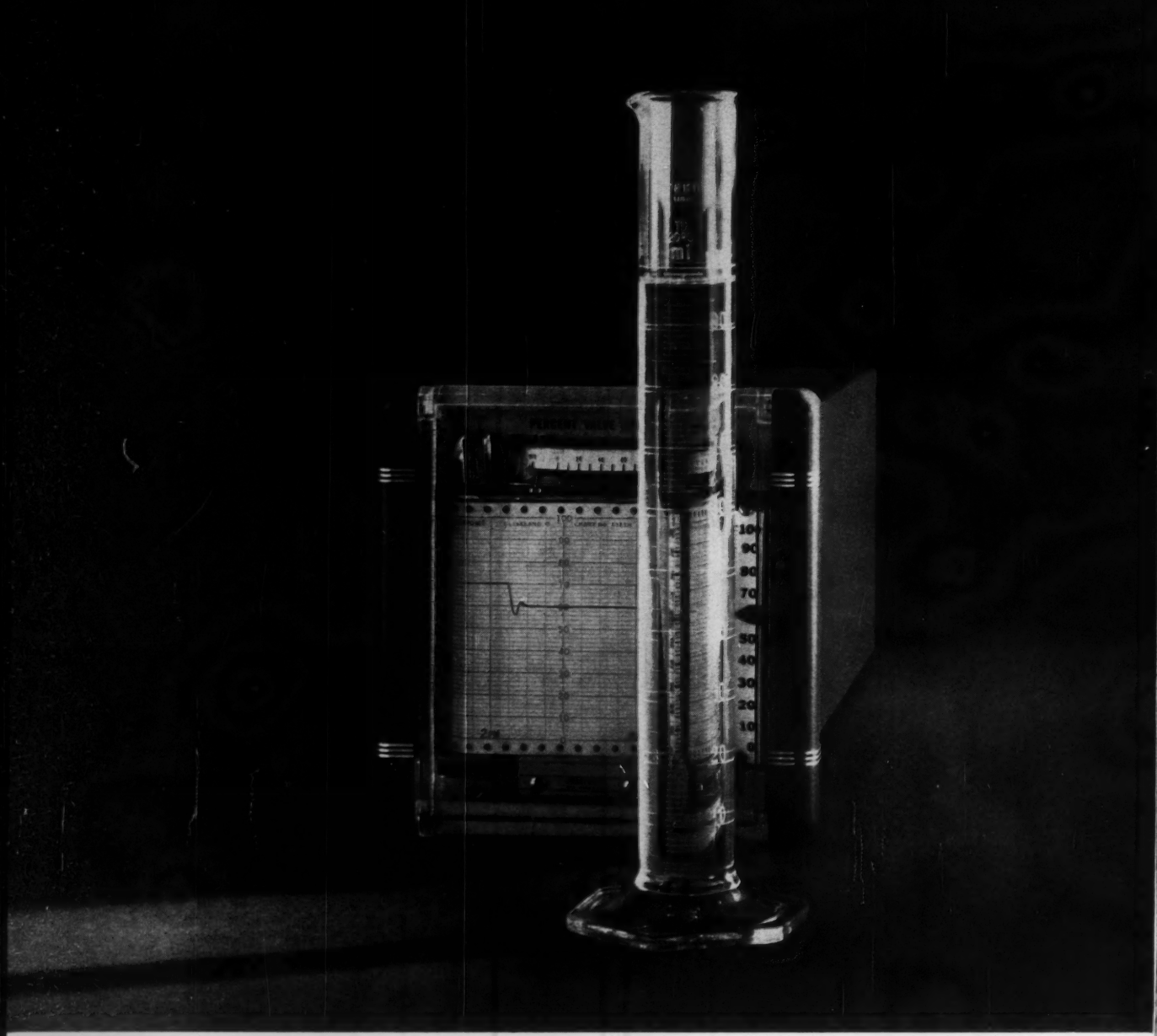
SPECIFICATIONS

Paper size: 8½" x 11"
Recording size: 7" x 10"
Overall dimensions: 11½" wide x 16½" long x 5" high
Net weight: 26 lbs.
Ambient temperature range: 0° to 55° C
Power requirements: 115 ± 10 v, 60 cps, 10 watts, standby; 100 watts, operating
Slewing speeds: 20"/sec both axes
Scales: 0.5, 1.0, 2.0, 5.0 mv/in.
Multiplier: X1, X10, $X10^2$, $X10^3$, $X10^4$
Plotting accuracy: 0.15% full scale
Input impedance: 1 megohm all ranges
Reference: Internal mercury battery or external ± 100 v from computer reference

OEM discounts available on all EI x-y recorders.

Electro Instruments, Inc.
3540 AERO COURT
SAN DIEGO 11, CALIFORNIA

CIRCLE 24 ON READER-SERVICE CARD



WE GOT OUR FEET WET 4 BILLION BARRELS AGO

4,000,000,000 barrels of oil (even greater quantities of chemicals) have gushed, gurgled, surged, spurted and, in some cases, oozed in precise response to Autronic® control loop signals.

There have been remarkably few troubles reported. In the beginning, of course, there were the inevitable design bugs. But now, 20,000 loops later, the bugs have all been worked out.

As a result, when you specify Swartwout, you get instrumentation that has shown—on the job—that it can do the job. You get all the advantages of electronic controls and the assurance and security that only a decade of field operation can provide.

Swartwout people know electronic instrumentation, and they would be glad to share that knowledge with you.

Interested? Send for Bulletin A-913.

SWARTWOUT

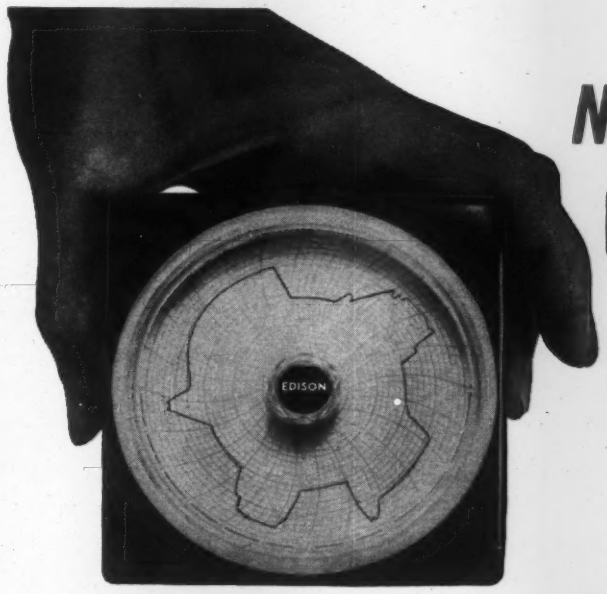
SWARTWOUT DIVISION, CRANE CO.

HOOKSETT INDUSTRIAL PARK • MANCHESTER, NEW HAMPSHIRE

SWARTWOUT . . . World Leader in Electronic Process Control

moving fast with CRANE

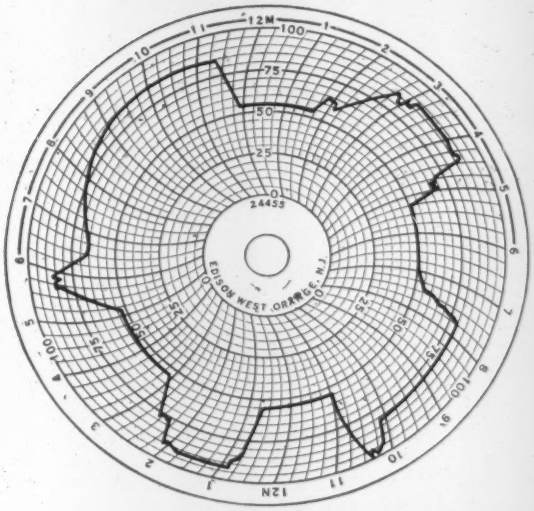
CIRCLE 14 ON READER-SERVICE CARD



NEW FROM EDISON . . .

OMNICORDER

A PRECISE MINIATURE INKLESS RECORDER



- **INEXPENSIVE**
- **RECORDS ANY VARIABLE**
- **REPLACES METERS OR INDICATORS**
- **PANEL OR BULKHEAD MOUNTED**
- **BUILT-IN VARIABLE CHART SPEED**
- **JUST 3¾″ x 3¾″ x 3″**

Now you can take advantage of a new, economical means of recording any variable that can be converted to an electrical signal. Thanks to Omnicorder, you need no longer rely on meters or indicators, even where cost factors or space restrictions would ordinarily dictate the use of these instruments.

Measuring just 3¾″ x 3¾″ x 3″, Edison's Omnicorder, a unique circular chart recorder, is so compact that nine units occupy just one square foot of space. Thoroughly legible, yet requiring no ink, pen or ribbon, Omnicorder is equipped with a simple three-speed adjustment which regulates chart rotation, thereby providing time sequences to meet varied needs. A flick of the switch gives users a choice of these sequences: one hour, seven hours and thirty hours per revolution — or one day, seven days and thirty days per revolution.

Omnicorder's simple, inexpensive construction assures dependable operation and a long, maintenance-free life. Four types of meter movements are available to measure a wide range of AC and DC electrical quantities, ranging from thermocouple outputs to currents as high as 100 amperes. No amplification is ever required, even for signals as low as 10 microamps.

For complete information on this rugged, maintenance-free Omnicorder, write for Catalog 3057.

Stylus operates through this slot. The measuring system is sealed off from any careless tampering.

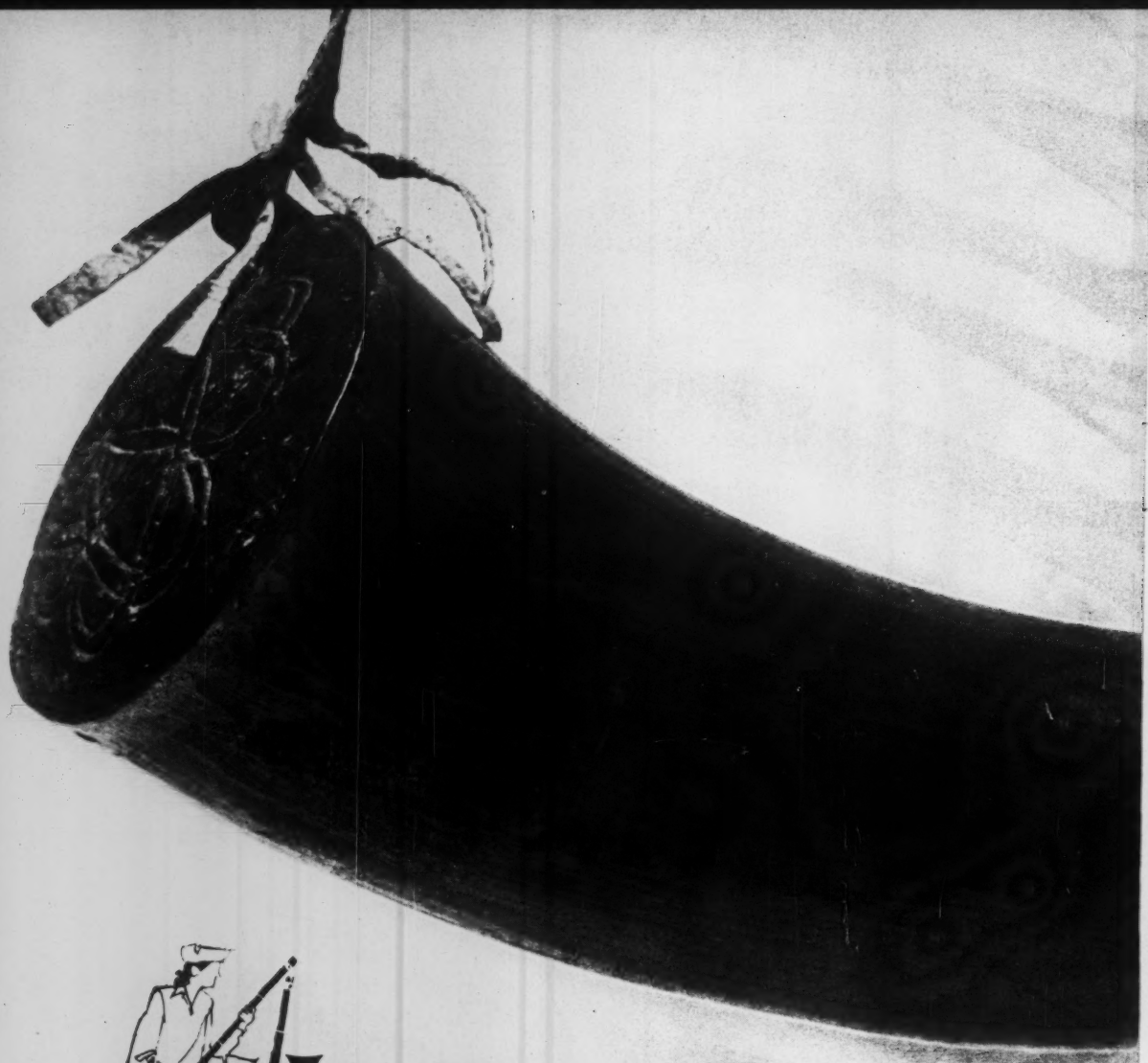
Zero Set Screw: Adjustment is made when measuring system is not printing and when the circuit to be recorded is disconnected.

Thomas A. Edison Industries
INSTRUMENT DIVISION
41 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 25 ON READER-SERVICE CARD

CIRCLE 26 ON READER-SERVICE CARD——→

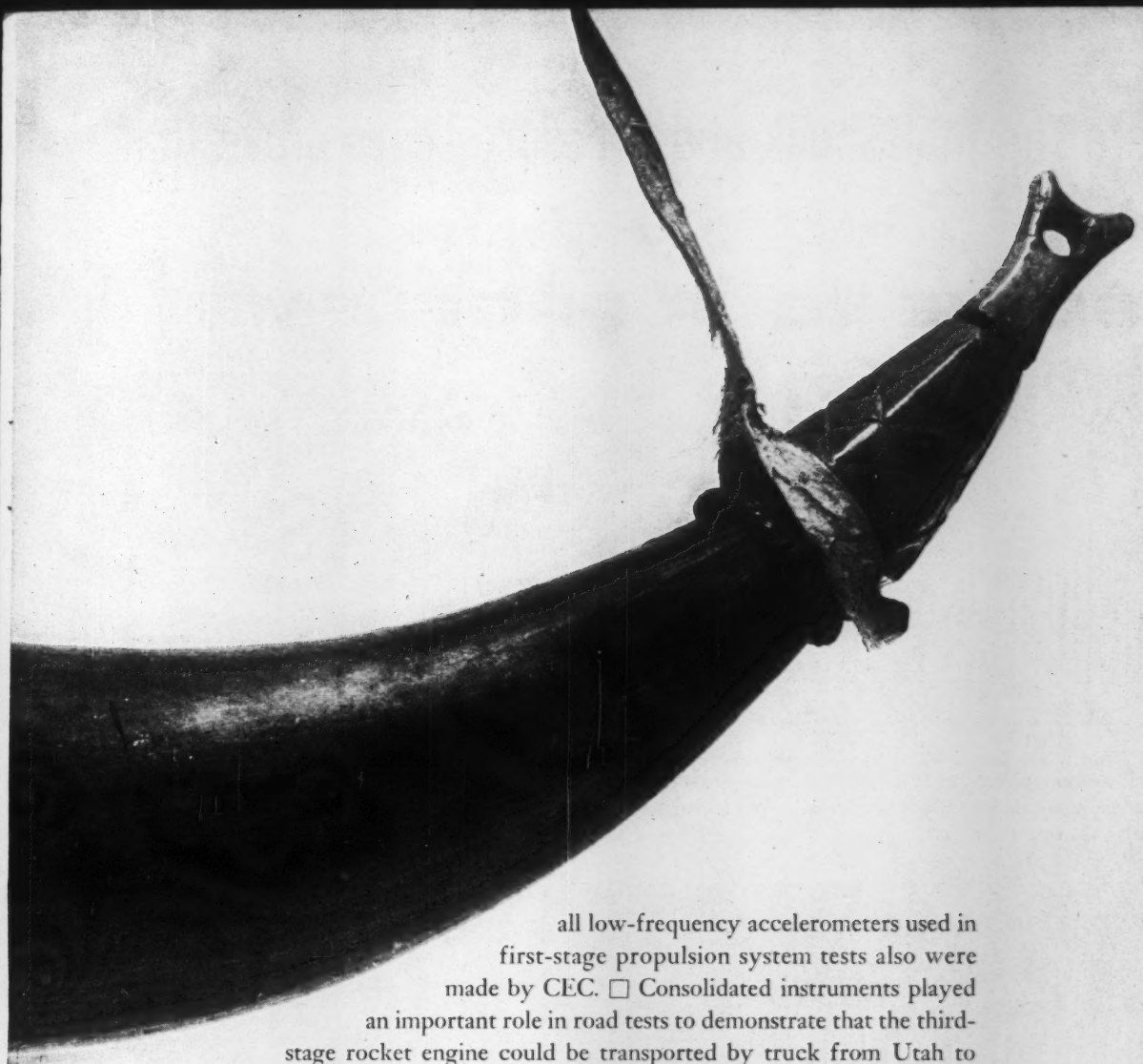
COURTESY OF THE HISTORY DIVISION, LOS ANGELES COUNTY MUSEUM



Instant Defense

The Minuteman at Lexington and Concord was ready at a moment's notice to defend his home. Today's Minuteman, a solid fuel, 6325-mile range ICBM -- launched from underground silos or railroad cars—can be readied in seconds, to bring a nuclear war home to any aggressor! □

Before and during its successful firing last February, Minuteman was tested on the ground, in transit, in trajectory. Much of this testing – measuring, analyzing, controlling, recording – was done with Consolidated Electrodynamics Corporation instruments. □ Transducers for test units of Minuteman are made by Consolidated. CEC oscillographs are used throughout FM/telemetry, PCM, and various ground support stations for the test program. □ The three data acquisition systems designed for road testing the first-stage rocket engine have relied on CEC print-out oscillographs to record accelerations. Various ground-test pressure transducers and



all low-frequency accelerometers used in first-stage propulsion system tests also were made by CEC. □ Consolidated instruments played an important role in road tests to demonstrate that the third-stage rocket engine could be transported by truck from Utah to such cities as Denver, Las Vegas, and Seattle, and returned to Utah and fired successfully. Three test trucks were equipped with instrumentation to measure shock, vibration, and engine environment. Mounted in the trucks were three CEC mobile instrumentation systems, each made up of a recording oscillograph, two carrier amplifiers, a tape recorder, and Consolidated's newest strain gage accelerometers. Purpose of the tests was to determine if handling and cradling of the engine could be improved and if strain and stress on motor cases were excessive. □ In mobility tests of Minuteman units carried by train, CEC provided all of the accelerometers used to determine the extent of shock and vibration to which the missile is subjected. □ Partners in this important defense project are Boeing Airplane Co., Space Technology Laboratories, Autonetics Division of North American, Thiokol Chemical Corporation, Hercules Powder Company, Aerojet-General Corporation, and Avco Corporation. □ CEC knows. These companies know. The world knows. Keep America's powder horns filled, maintain Instant Defense, and no enemy will dare to attack. That's the promise of the Minuteman.

CONSOLIDATED ELECTRODYNAMICS / pasadena, california **CEC**

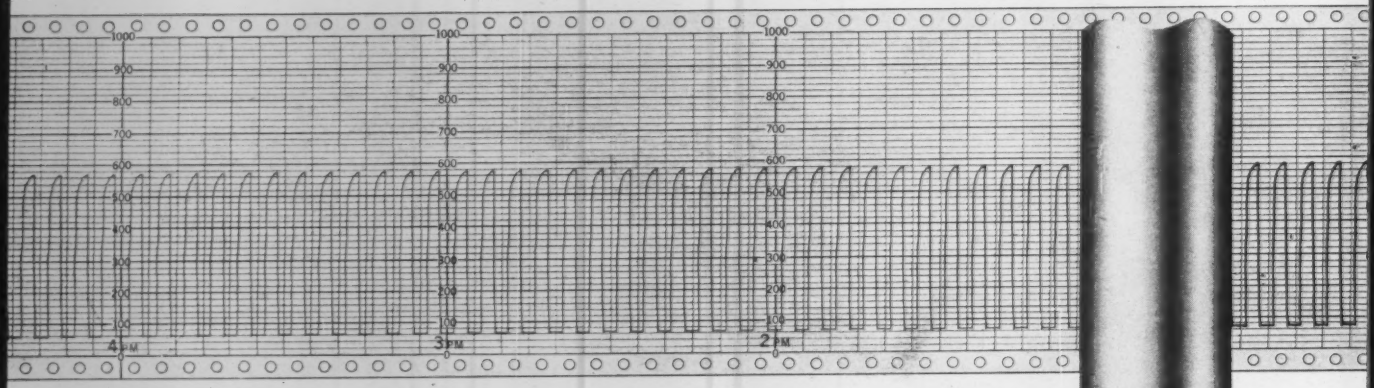
DATA RECORDERS DIVISION • DATALAB DIVISION • TRANSDUCER DIVISION • ANALYTICAL & CONTROL DIVISION • CONSOLIDATED SYSTEMS CORP. • CONSOLIDATED VACUUM CORP.

A SUBSIDIARY OF **Bell & Howell** • *FINER PRODUCTS THROUGH IMAGINATION*

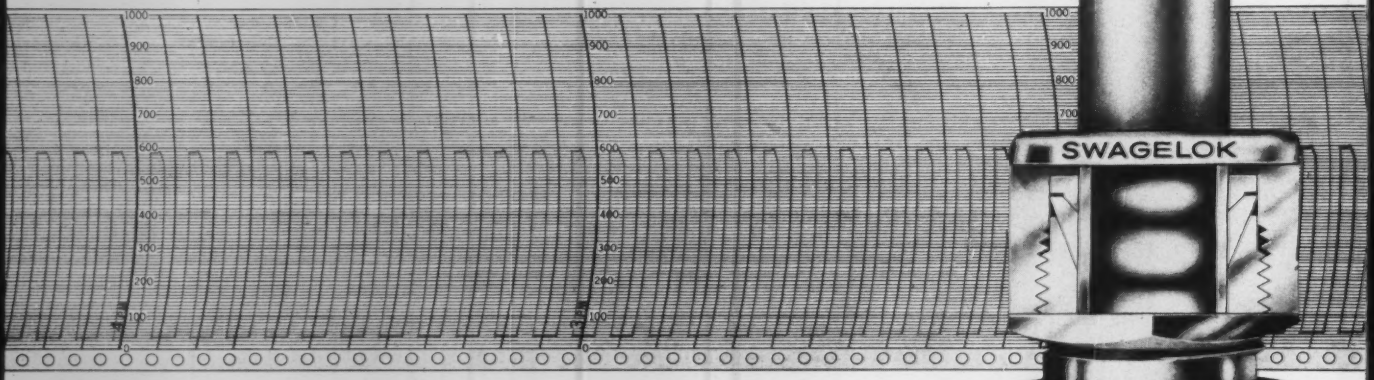
Severe Thermal Shock and Pressure Tests prove that

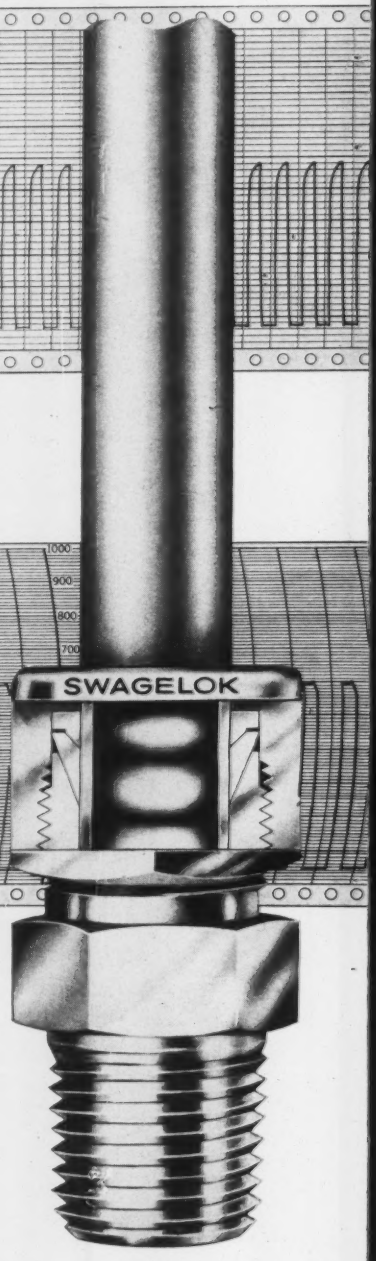
Swagelok® TUBE FITTINGS

SOLVE YOUR PROBLEMS



TEMPERATURE VS TIME RECORDING: The peak temperatures 580° to 600° F. occurred during the maximum pressure period. 750° F. steam was used but inability to keep insulation intact due to severity of the thermal shocks limited the maximum temperature. The minimum temperatures occurred during the cold water flush.





PRESSURE VS TIME RECORDING: The maximum pressures on the chart were produced by 600 psi superheated steam at a source temperature of 750° F. The minimum pressures were the result of opening the system dump valve and flushing with 50° F., 500 psi cold water.

The tests recorded on the above charts were conducted on one inch carbon steel hydraulic tubing (ASTM-A-179) using carbon steel SWAGELOK Fittings. Thirteen to sixteen SWAGELOK Tube Fitting connections were in the systems and 1200 severe thermal shocks were applied on each of two different tubing configurations without leaks or failure. The conditions used in this test were considered casualty or mal-operation conditions and are not recommended practice for any system design.

These tests prove that for steam system instrumentation and steam tracing service, SWAGELOK Tube Fittings solve your problem.

Swagelok® TUBE FITTINGS

Crawford Fitting Company • 884 East 140th Street • Cleveland 10, Ohio • Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

←CIRCLE 26 ON READER-SERVICE CARD

CIRCLE 27 ON READER-SERVICE CARD

One-inch body diameter
valve line

Completely new series of **SKINNER** solenoid valves facilitates further miniaturization

Here's a really miniature stainless steel solenoid valve with all the features of a larger valve

think small

VALVE SHOWN ACTUAL SIZE

- Now designers of pneumatic and hydraulic control systems and devices requiring high flow in smaller packages can **specify miniature solenoid valves from shelf stock.**
- These new B Series valves are so small and so new that ⅛" NPT was too large, therefore 1/16" PTF connections were selected. Fittings are included to make fluid connections with ⅛" tubing.
- Never before have there been valves like this—**really miniature in over-all size, pipe size, and weight.**

VITAL STATISTICS

Type	3-way normally closed
Over-all size	1" x 2 1/16"
Orifice size	3/64" Inlet and Outlet
C_v factor	.045
Fluid connections	1/16" PTF (adapted for ⅛" tubing)
Weight	5 oz.
Maximum operating pressure	150 PSI
Vacuum	Down to 5 microns

Skinner Distributors are now stocking the first of these new valves—the three-way normally closed. Three-way normally open and directional control, two-way normally open and normally closed, and higher pressure models will be on the market soon.

For complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

B SERIES FEATURES

No leakage—Soft, synthetic inserts provide bubbletight sealing. Seats have smooth rounded edges—no cutting of insert material.

Mounting by means of two tapped mounting holes (8-32) in valve body. Can be mounted in any position.

Voltage—Coils available in most AC and DC voltages. Heat rise meets U.L. standard of 85°C maximum for continuous duty. Maximum power requirement—7 watts.

Electrical housings are available with single grommet or ¼" NPT conduit which can be rotated 360°.

Media—B Series valves may be used with all common media including many semi-corrosive fluids.

Corrosion-resistant—Stainless steel body and internal parts.

SKINNER ELECTRIC VALVES®

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

NEW DORSETT "20" SERIES

provides maximum telemetry system flexibility!

- Requires Less Power
- Meets Most Rugged Environmental Conditions
- Die Cast Construction

SOLID STATE COMPONENTS AVAILABLE FOR "20" SERIES PACKAGING

- TR-20 2-watt FM Transmitter, 225 - 260 mc.
- TR-21 2-watt FM Transmitter, 136 - 137 mc.
- 0-20 Subcarrier Oscillator
- MVO-20 Millivolt Subcarrier Oscillator
- ACA-20 Low Level AC Amplifier
- DCA-20 Low Level DC Amplifier
- PWM-20 Pulse Width Modulator
- PS-20 Regulated Power Supply

MODULAR PACKAGING DESIGN of the new "20" series line of telemetering components and systems lets you put more telemetering equipment in less space. Every system component has been packaged in compatible modules identical in height (2.25") and width (1.875"), with thicknesses of one, two, or four units (.875" per unit). These standard modules permit a wide range of system configurations, and make future modification of basic systems easy and economical.

EVERY "20" SERIES COMPONENT utilizes silicon semi-conductor circuitry—no tubes anywhere. The typical "20" series 12 channel system including transmitter, weighs less than 5 pounds, draws less than 20 watts from a 28 volt supply, and exceeds military specifications for reliability and performance throughout extreme missile environments.

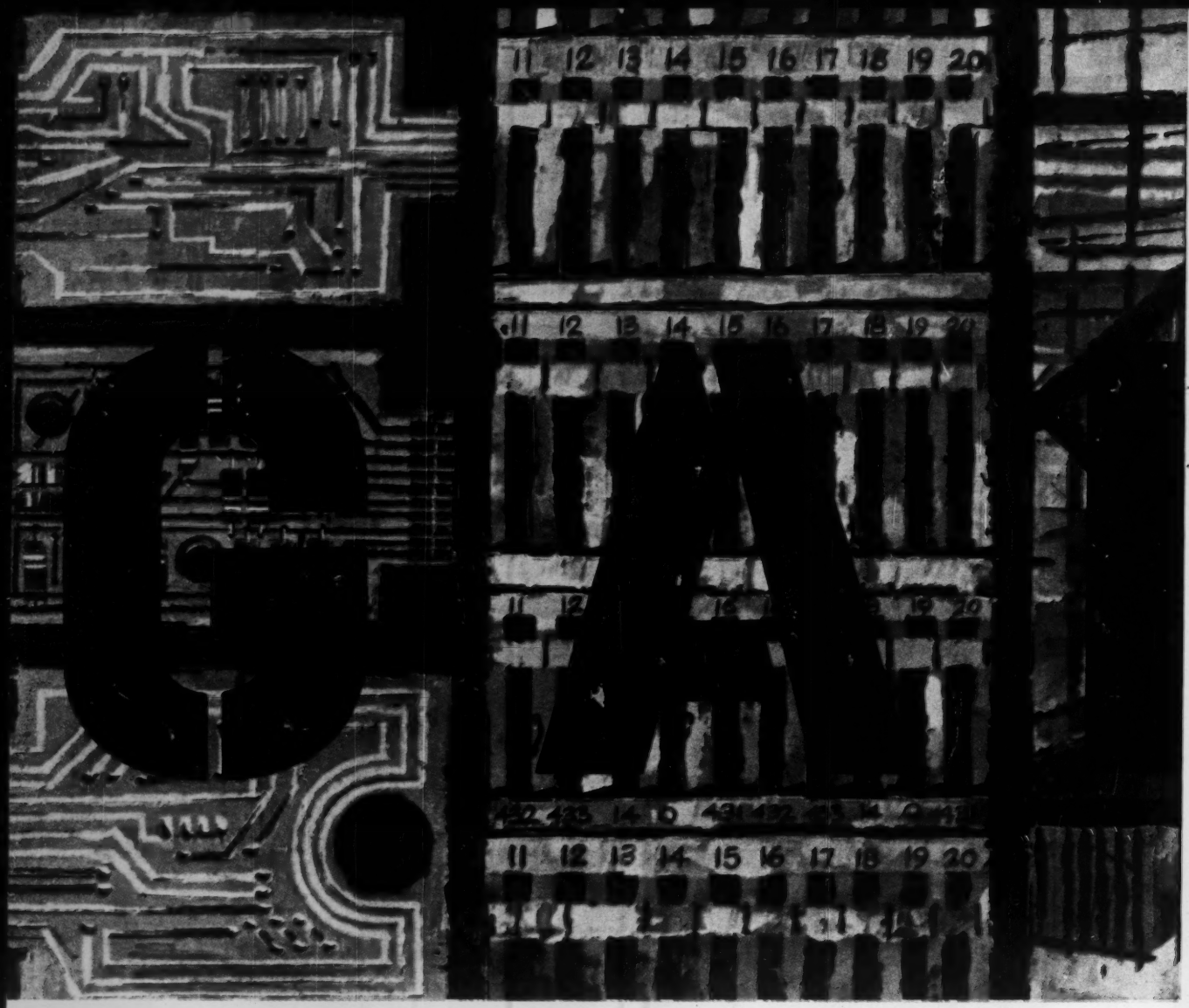
FOR YOUR NEXT TELEMETERING REQUIREMENT let Dorsett take the problems out of system packaging with a "20" series telemetry system. Your inquiries or specifications will receive a prompt reply.

DORSETT ELECTRONICS, INC.

P. O. Box 862, Norman, Oklahoma, Ph: JEfferson 4-3750

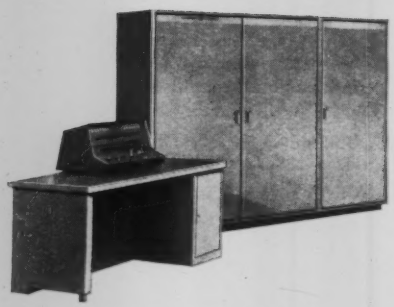
CIRCLE 28 ON READER-SERVICE CARD

CIRCLE 29 ON READER-SERVICE CARD



G Gathers automatically the information the operator needs to supervise the plant.

A Alarms off-limit quantities... automatically warns when an unsafe value occurs and logs all points exceeding pre-set limits.



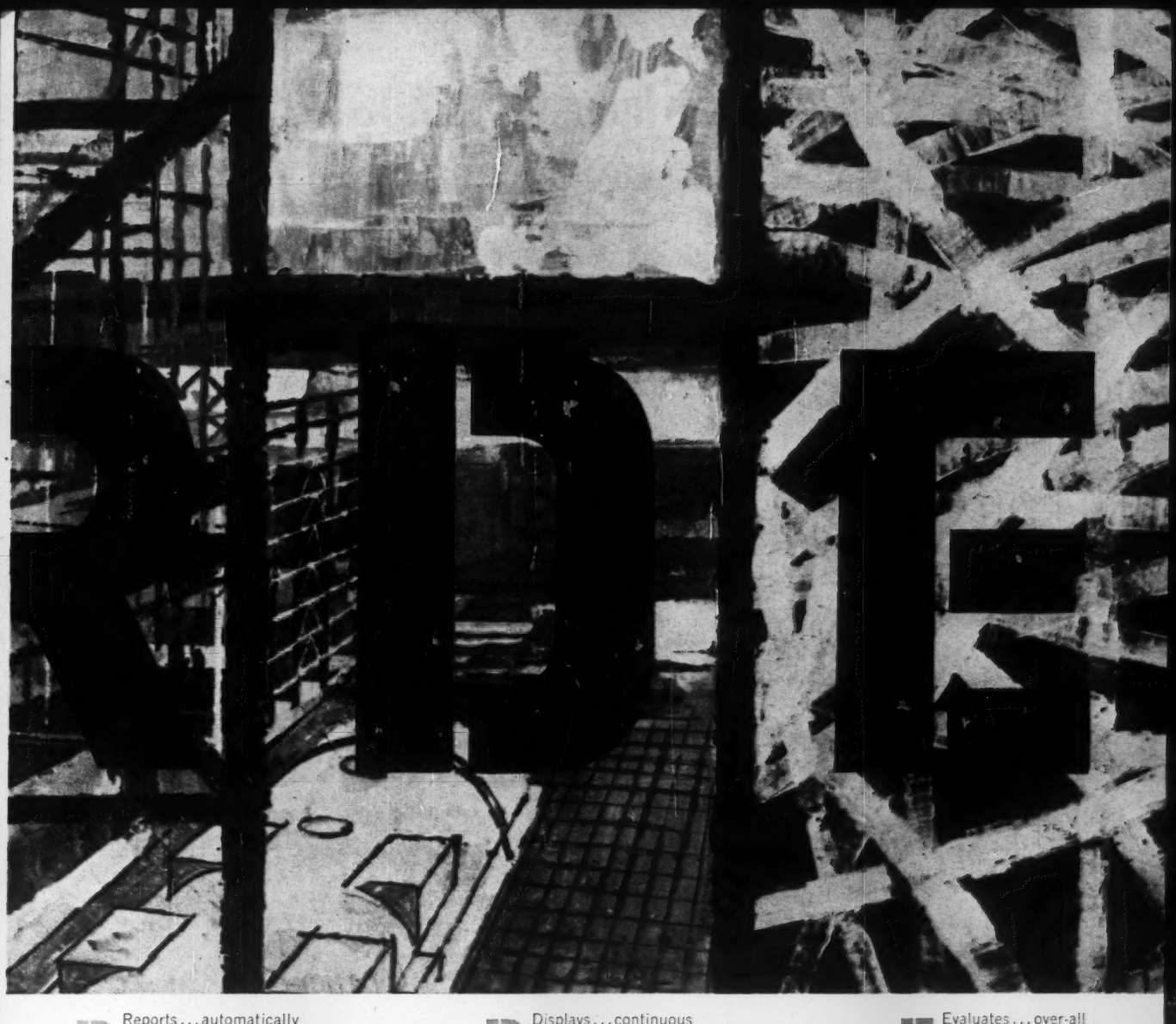
NEW GENERAL ELECTRIC COMPUTER SYSTEM

designed solely for electric utility steam power plant data processing

HERE'S HOW GENERAL ELECTRIC'S ADVANCED DESIGN SYSTEM LOWERS OPERATING AND MAINTENANCE COSTS...

GARDE is General Electric's process computer system designed especially to meet the problems and needs of electric steam plant data processing. The GARDE system gathers, alarms, reports, displays, and evaluates data from several

PCA-1



R Reports... automatically prepares a complete log of all operating conditions hourly or on demand.

D Displays... continuous visual display of any input or computed value that the operator chooses.

E Evaluates... over-all plant and key component performance hourly—or on demand.

hundred inputs located throughout the plant. It warns of abnormal deviations in those process conditions which cause equipment stress and inefficient operation. Early detection of these saves dollars in equipment maintenance and increases operating efficiency.

In addition, the GARDE system checks itself—detecting faulty sensors and other components. Its continuous reports are invaluable in periods of rapid operational changes. One of its provisions guides the operator through complex plant operating routines, helping him avoid errors and resultant equipment outage.

GARDE system evaluates these key plant operations: Boiler efficiency • Turbine Generator Heat Rate • Station Heat Rate • Correction of Heat Rates to Bogey Conditions • High Pressure and Intermediate Pressure Turbine Efficiency • Feedwater Heater and other Equipment Performance • Condenser Performance.

General Electric was able to design the GARDE system because it leads all manufacturers in process computer systems installed or ordered by the utility industry. The near-million man-hours of application and research in its design were spent in implementing systems for users. Out of this experience, came the GARDE process computer system.

Investigate this newest development in data processing for steam plants—contact your nearest General Electric Apparatus Sales Office or Process Computer Section, Industry Control Department, P.O. Box 2918, Phoenix, Arizona.

In Canada, contact Canadian General Electric Apparatus Sales Department, Peterborough, Ontario.

Outside the U.S. and Canada, contact International General Electric, 150 East 42nd Street, New York 17, New York.

CIRCLE 30 ON READER-SERVICE CARD

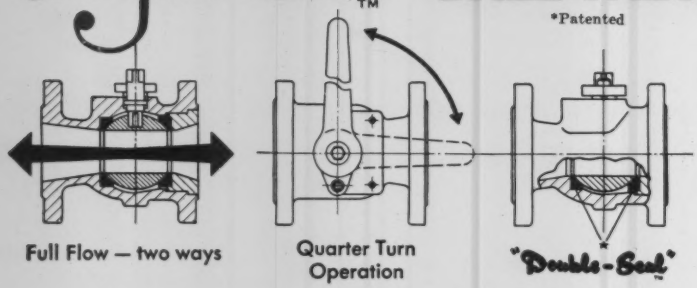
Progress Is Our Most Important Product

GENERAL ELECTRIC

Close-up of Industry's MOST VERSATILE *BALL VALVE

jamesbury "Double-Seal"™ BALL VALVES

*Patented



Full Flow — two ways | Quarter Turn Operation | "Double-Seal"™

MATERIALS

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Special Teflon compounds, and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.

SIZES

Screwed End: ¼" through 8".

Flanged:
150# series—½" through 12"
300# series—½" through 8"*
*10" and 12" on application
*600# series on application

©Jamesbury Corp. 1961

Ask for complete "Double-Seal" Ball Valve Literature.

JAMESBURY CORP., 78 NEW STREET, WORCESTER, MASS.

DISTRIBUTORS IN PRINCIPAL CITIES

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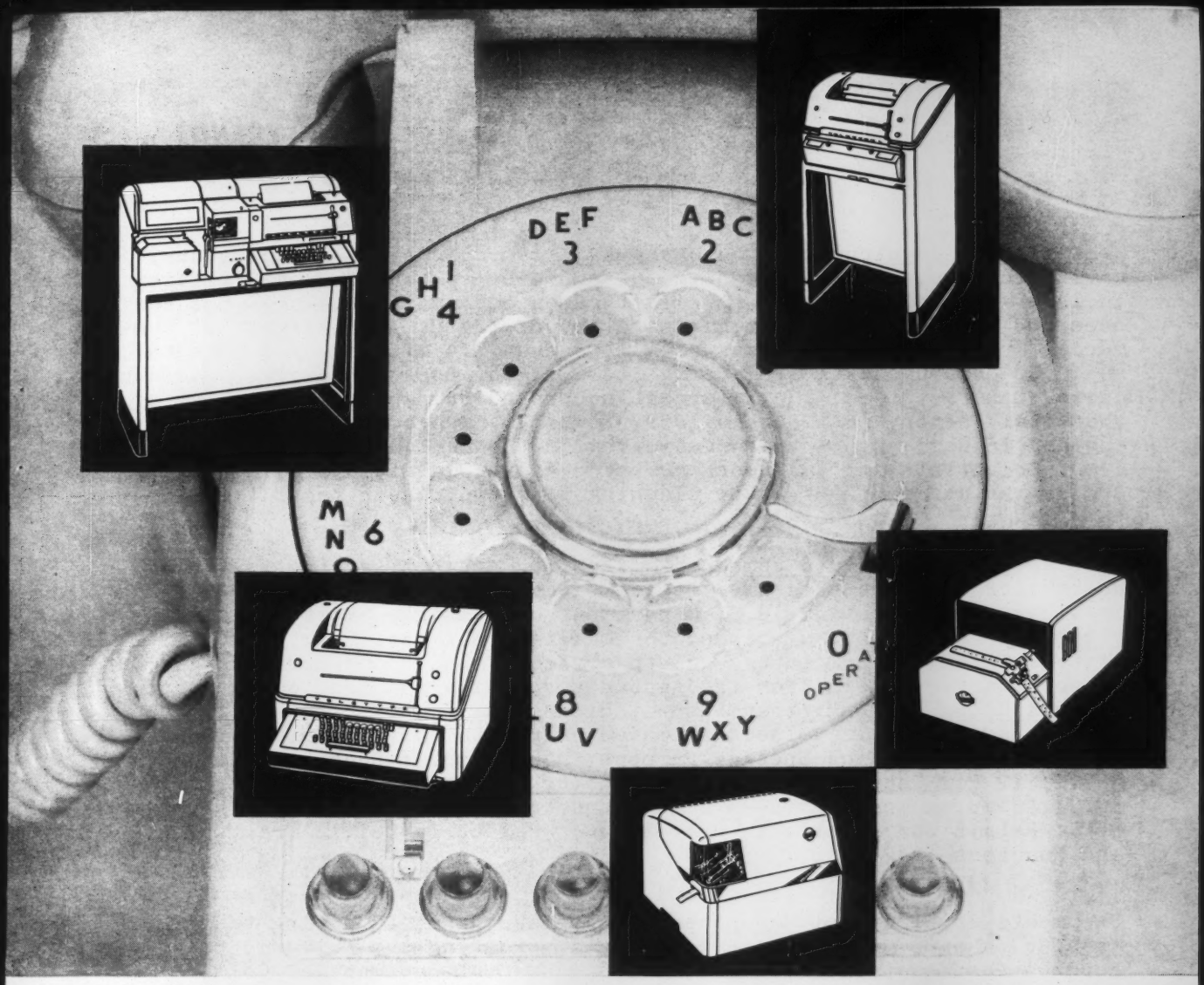
CIRCLE 32 ON READER-SERVICE CARD→



Teletype equipment in Data-Phone service

All Teletype sending and receiving equipment—page printers, tape punches and tape readers—can be used in Data-Phone service, the new Bell System method of data transmission via regular telephone lines.

Data can be speeded over local or long distance lines—to a single destination or to several destinations simultaneously. The data can be received on plain message paper . . . punched paper tape . . . or marginally perforated business forms of almost any size. And always there is a "home record" of what is sent.

Significant paper work simplification and time savings can be achieved in handling accounting and billing information, inventories, payrolls, invoices, sales orders, ticket pick-up and numerous other kinds of business detail. If desired, punched tape can be obtained as a by-product of both sending and receiving operations, for later use with business machines.

A growing number of firms are already using Teletype equipment over Data-Phone circuits. For example, companies that purchase large quantities of airline space place orders by phone, then receive tickets on Teletype printers right in their own offices. With this method, tickets are received faster, messenger service is eliminated, and records for accounting purposes are automatically provided.

Teletype Corporation manufactures page printers and tape units such as the Model 28 equipment illustrated above for the Bell System and others who require the utmost reliability from their data communications facilities.

If you would like to investigate the advantages of Teletype equipment for your business, write to Teletype Corporation, Dept. 22-F, 5555 Touhy Avenue, Skokie, Illinois.

TELETYPE®
CORPORATION • SUBSIDIARY OF *Western Electric Company* INC.

Research and development in the field of semiconductors—transistors, crystal diodes, and related devices--amounted to more than $70 million in 1959—the latest year for which figures are available—says the Business and Defense Services Administration of the U.S. Department of Commerce. Private industry underwrote more than $54 million of this total, and U.S. Government the remaining $16 million. BDSA surveyed 60 semiconductor manufacturers. The 3 largest accounted for approximately 39% of the total factory shipment in 1959. Some 34,700 production workers were engaged in semiconductor manufacturing in the period January to April 1960. Scientists and engineers numbered approximately 6,200. More than 60% of the manufacturers were planning to expand their facilities.

Shipments of electronic components declined about 5% during the third quarter of 1960, reports Electronics Division, Business and Defense Services Administration, U.S. Department of Commerce. Most of this decline was in components shipped for military end-use. Only the output of television picture tubes, quartz crystals, and transformers exceeded second quarter levels. For the second successive quarter, output of semiconductor devices (transistors, diodes and rectifiers, and related devices) declined in value. Estimated shipments third quarter, 1960 (millions): Power and Special Purpose Tubes—$58.7; Receiving Tubes—$87.2; TV Pix Tubes—$69.7; Semiconductor Devices—$60.8; Capacitors—$61.4; Complex Components—$10.3; Connectors—$40.1; Quartz Crystals—$5.7; Relays for Electronic use—$41.6; Resistors—$61.1; Transformers and Reactors—$42.6

Shipments of electronic components increased about 4% during the fourth quarter of 1960, in contrast to 5% decline during the third quarter, reports the Electronics Division, BDSA, U. S. Department of Commerce. Total shipments for 1960 were 10% over 1959. The quarterly rise was due to increased requirements for military and industrial type electronic components. Shipments of consumer type components declined.

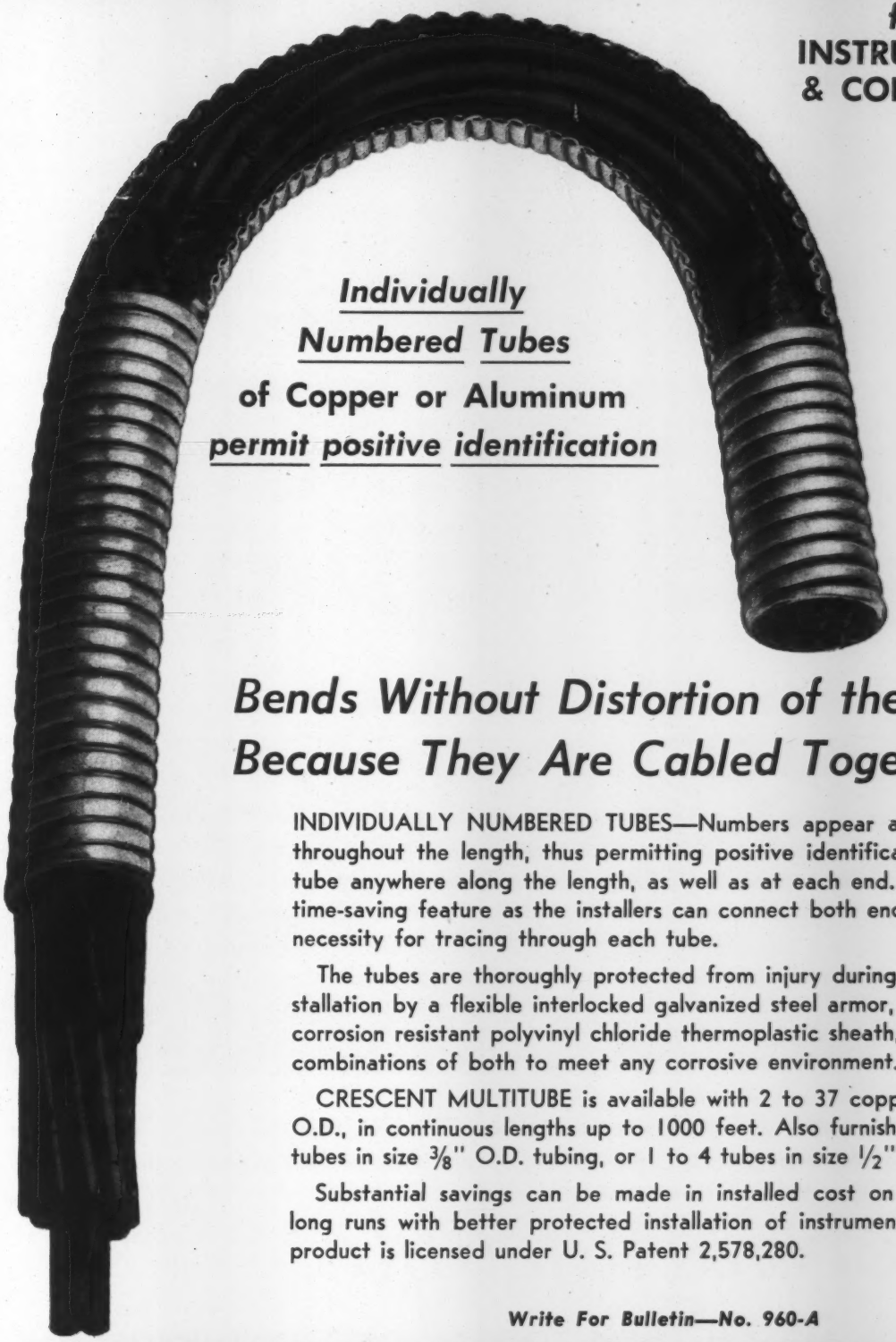
Factory Sales of transistors are reported by Marketing Data Department of Electronic Industries Association:

	Factory Sales (Units)	Factory Sales (Dollars)
February	13,270,428	$25,699,625
January	12,183,931	22,955,167
Year-to-date 1961	25,454,359	48,654,792
Year-to-date 1960	19,134,292	49,546,150

Japanese exports of electronic products to the United States during the third quarter 1960 totaled $24.3 million, a slight increase- over the $24.1 million in the third quarter 1959, the Electronics Division, BDSA, U. S. Department of Commerce reports. Exports to the U. S. during January-September 1960 increased by 37% over the same period 1959, whereas exports to the rest of the world increased by 81%. Japanese exports of electronic products to all countries totaled $131.2 million in the first three-quarters of 1960, compared with $83.8 million in the same period 1959.

CRESCENT ARMORED MULTITUBE

for INSTRUMENTS & CONTROLS



Individually Numbered Tubes

of Copper or Aluminum

permit positive identification

Bends Without Distortion of the Tubes Because They Are Cabled Together

INDIVIDUALLY NUMBERED TUBES—Numbers appear at 2" intervals throughout the length, thus permitting positive identification of every tube anywhere along the length, as well as at each end. This is a real time-saving feature as the installers can connect both ends without the necessity for tracing through each tube.

The tubes are thoroughly protected from injury during and after installation by a flexible interlocked galvanized steel armor, TYPE CA, or corrosion resistant polyvinyl chloride thermoplastic sheath, TYPE CT, or combinations of both to meet any corrosive environment.

CRESCENT MULTITUBE is available with 2 to 37 copper tubes, 1/4" O.D., in continuous lengths up to 1000 feet. Also furnished in 1 to 12 tubes in size 3/8" O.D. tubing, or 1 to 4 tubes in size 1/2" O.D.

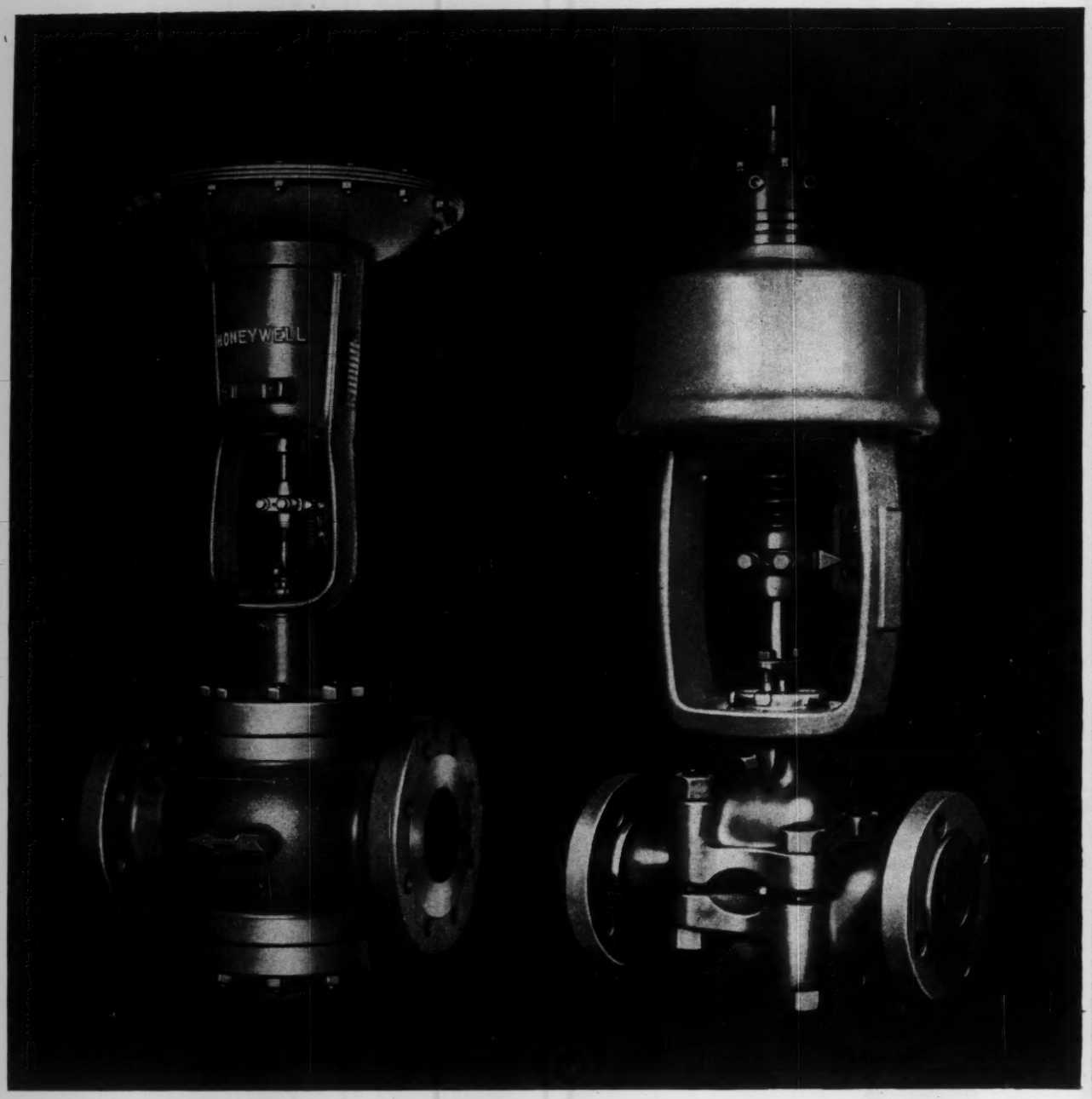
Substantial savings can be made in installed cost on moderate to long runs with better protected installation of instrument tubing. This product is licensed under U. S. Patent 2,578,280.

Write For Bulletin—No. 960-A

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON 5, NEW JERSEY

CIRCLE 36 ON READER-SERVICE CARD

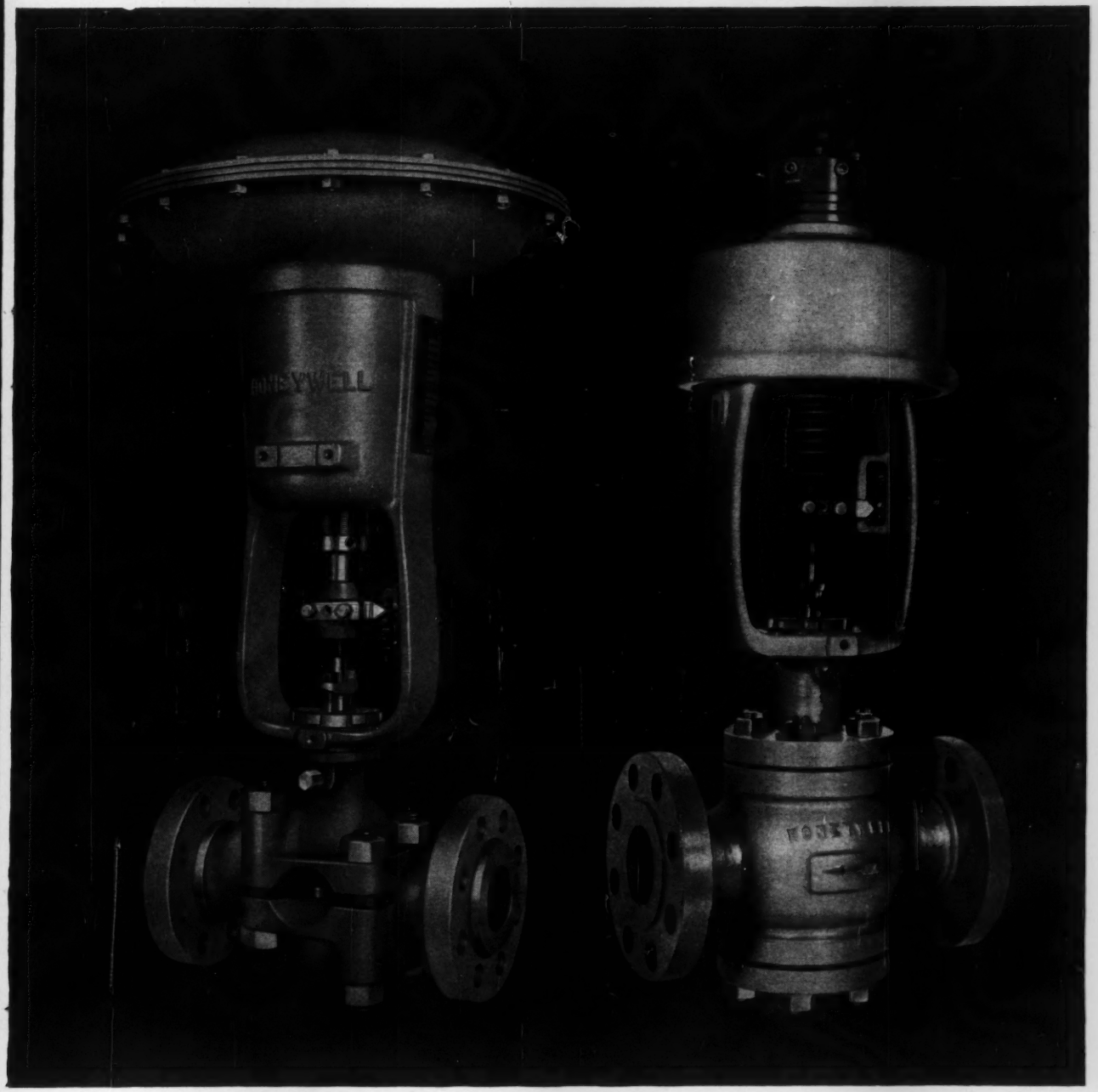


The lineup, left to right—Diaphragm actuator, globe body . . . Cylinder actuator, split body . . . Diaphragm actuator, split body . . . Cylinder actuator, globe body.

Interchangeable!

MIX THEM, MATCH THEM TO THE JOB . . . AND SAVE!

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.



Honeywell's split-body and globe-body control valves team up beautifully with Honeywell cylinder and diaphragm type actuators. Use either actuator with either valve. The beauty lies both in the economy and perfect matching to the application made possible by this interchangeability. The "mix and match" versatility of Honeywell valves and actuators lets you select the exact degree of performance you require. No need to push a valve beyond its design limits, on one hand, or to pay for more performance than you need, on the other. You get the best valve-actuator combination for a given application, at the lowest cost. The new Honeywell "Valve Size Computer" helps you make your *mix and match* selection . . . send for yours today. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

Honeywell

First in Control

SINCE 1885

CIRCLE 37 ON READER-SERVICE CARD

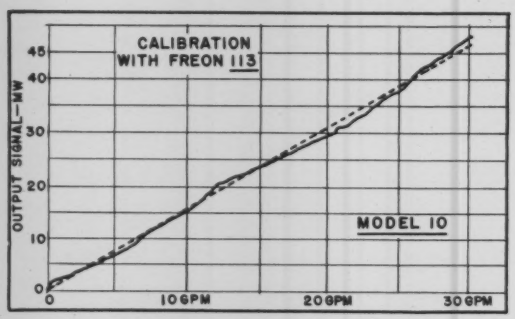
New Flow Transducer

WIDE RANGE LINEAR STRAIN GAGE OUTPUT

Standard Controls' Flow Transducer Accurate to 2% from 0 Flow to Full Scale. Available in Ranges of 0-0.5 gpm through 0-200 gpm.

Based on the cantilever reed principle, Standard Controls' new flow transducer produces a linear output with less than 2% full scale deviation, from 0 to full rated flow. Dynamic response is faster than 90% of step function input in less than 10 milliseconds.

NO MOVING PARTS. Mechanically simple, the new transducer has no rotating parts, no bearings, no hinge action. All movements are cantilever bending.



Actual linearity curve for Standard Controls new flow transducers. (0 to 30 gpm ranges.)

BONDED STRAIN GAGE DESIGN. Electrically, the design consists of a 4-active-arm, bonded strain gage bridge which senses flow against a cantilever reed in the flow stream. Sensitivity is 4 mv/volt. Flow is uni-directional. Repeatability errors are less than 0.25% of full scale. Environmental range is −65°F to +300°F.

DIMENSIONS AND OPTIONS. A typical unit weighs 8 ounces and occupies a volume of 1¼" D x 1" W x 4" H. For telemetry purposes, a signal conditioning amplifier is incorporated to provide a 5 volt full scale output. Electrical and mechanical configurations can be modified for specific applications.

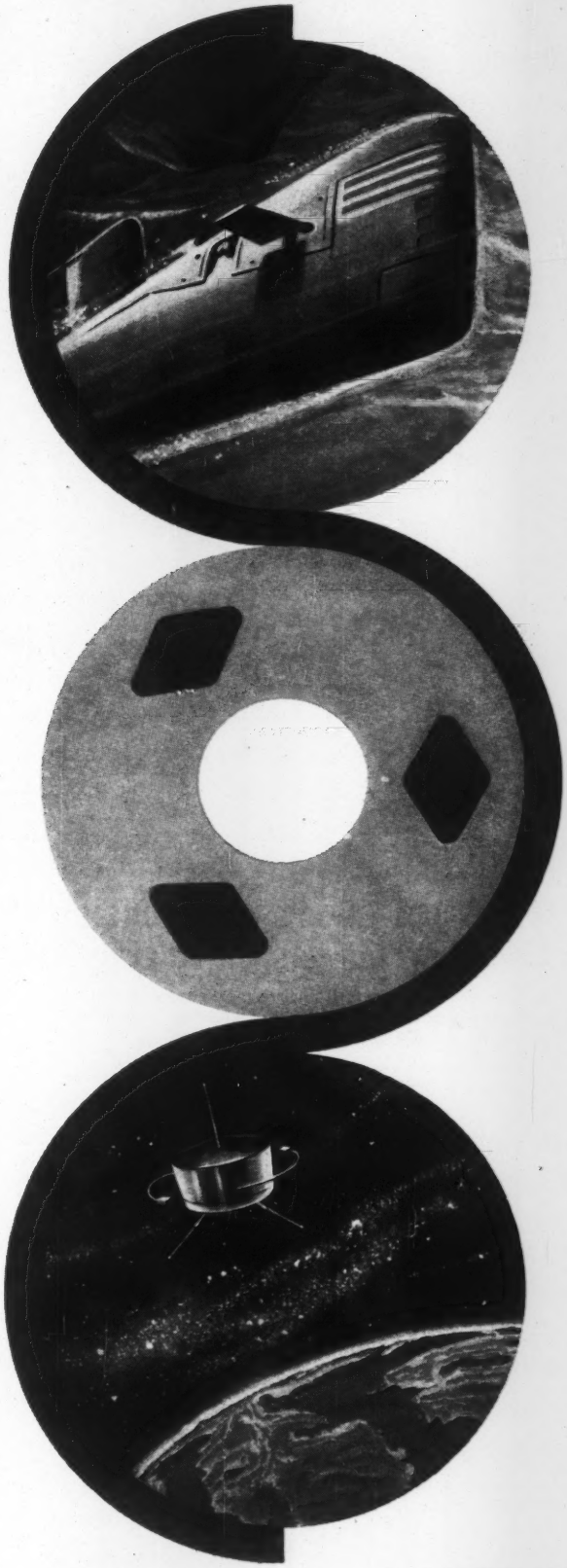
NEED MORE INFORMATION?
Call your nearby Standard Controls engineering representative whose name and phone number is listed below, or write to:

Standard Controls INC.

STANDARD CONTROLS
1130 Poplar Place So. • Seattle, Washington
Phone: EAst 4-8888

STANDARD CONTROLS' REPRESENTATIVES: CEDAR RAPIDS, Iowa, Engineering Services Co., Phone: EMpire 5-6183 • CIRCLE PINES, Minnesota, Pat Lind Electronics Co., Phone: SUnset 4-3827 • DALLAS, Texas, Ammon and Champion Company, Phone: FLeetwood 7-3939 • ENGLEWOOD, Colorado, Thorson Company, Phone: SU 9-1841 • HERMOSA BEACH, California, Systems Instrument Sales Co., Phone: FRontier 9-8251 • IDAHO FALLS, Idaho, Seatronics, Inc., Phone: JAckson 2-7992 • KANSAS CITY, Missouri, Engineering Services Co., Phone: PL 3-7227 • PALO ALTO, California, Egbert Engineering of California, Phone: DA 6-1387 • SEATTLE, Washington, Seatronics, Inc., Phone: EAst 3-8545 • ST. LOUIS, Missouri, Engineering Services Co., Phone: PArkview 6-2233 • WELLESLEY HILLS, Massachusetts, John J. Goode Associates, Phone: CEdar 5-0552 • WICHITA, Kansas, Engineering Services Co., Phone: MUrray 5-3751

CIRCLE 38 ON READER-SERVICE CARD



SOUNDCRAFT INSTRUMENTATION TAPE IN SPACE AND UNDERSEA WITH TIROS II* AND THE SEA DRAGON

The Tape Selected For The Video System In Tiros II! Orbiting with the Tiros Weather Satellite II, developed by RCA for the National Aeronautics and Space Administration, Soundcraft Tape is used exclusively in both narrow and wide angle video tape systems. Only 3/8 of an inch wide, this tape records longitudinally rather than across the width and is the result of over five years of research.

On The Nuclear Submarine, Sea Dragon, the first undersea magnetic video tape recorders also developed by RCA, used Soundcraft instrumentation tapes to record and store data on under-ice characteristics of icebergs and ice flows. As man probes deeper and deeper into the unknown, science continues to call on the world's most modern tape plant for reliable magnetic tapes.

Discover how Soundcraft's consistent record of accomplishment can be extended and applied to fulfill your recording needs. Write for complete literature.

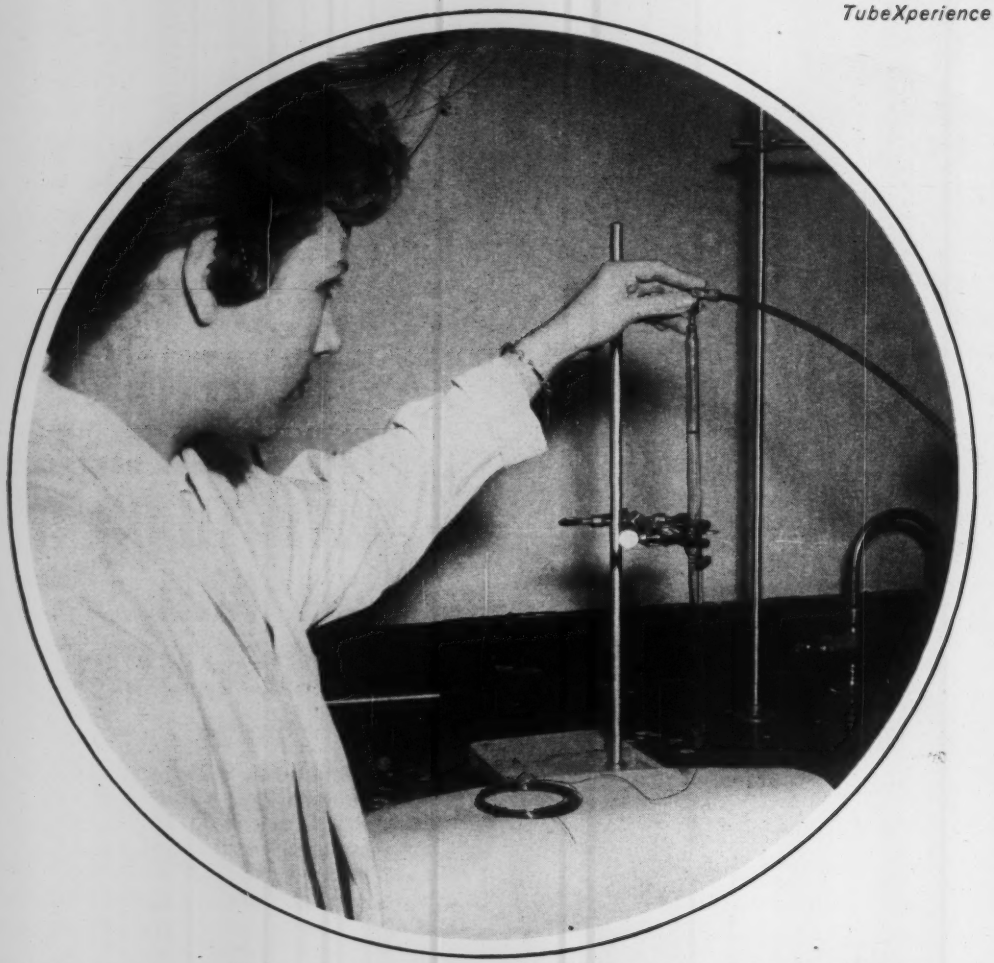
*Soundcraft Instrumentation Tape is, of course, used in Tiros I, and in other vital space projects as well.

REEVES SOUNDCRAFT CORP.

Main Office: Great Pasture Road, Danbury, Connecticut
New York: 10 East 52nd St. ■ Chicago: 28 East Jackson Blvd.
Los Angeles: 342 North LaBrea ■ Toronto: 700 Weston Road

R-131

CIRCLE 39 ON READER-SERVICE CARD



NOW! small-diameter stainless steel tubing with consistent ID size and surface uniformity for gas chromatography

Beginning in 1958, several colleges, universities and industrial instrument firms asked us to contribute from our specialized tubing knowledge to their gas chromatography development programs and we gladly acceded. Research on tubing up to this time had been limited mostly to glass, copper and plastic materials. Higher processing temperatures and problems of corrosion resistance called for new materials. Testing of various stainless steels and nickel alloys followed.

Today, as a result, we at Superior offer a number of stainless steel analyses and 30% cupronickel for this purpose—all available in standard capillary tubing, miniature tubing, and tubing for packed columns. These analyses and tubing types offer the following outstanding advantages:

- Highly desirable ID surface and size uniformity to accept a wide variety of coatings
- Nonpolar surface with respect to nonmetallic organic compounds
- Excellent corrosion resistance to most compounds and reactive materials being studied, even at high temperatures
- Relative inertness to all organic compounds
- Excellent heat transfer properties
- Great strength and resistance to breakage
- Ease in bending and general fabrication—compact columns can be formed eliminating the possibility of obstructions during chromatogramming of the sample
- Proved durability and higher efficiency than other materials
- Minimal danger of reacting with partitioning liquids
- Leakproof system—connections can be readily made with plastic sleeves
- Lessened cleaning problems, reproducible coatings made possible

Complete information, including analyses, sizes, lengths, and coil diameters, is given in Bulletin 110, "Tubing for Gas Chromatography." Write for your copy today. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

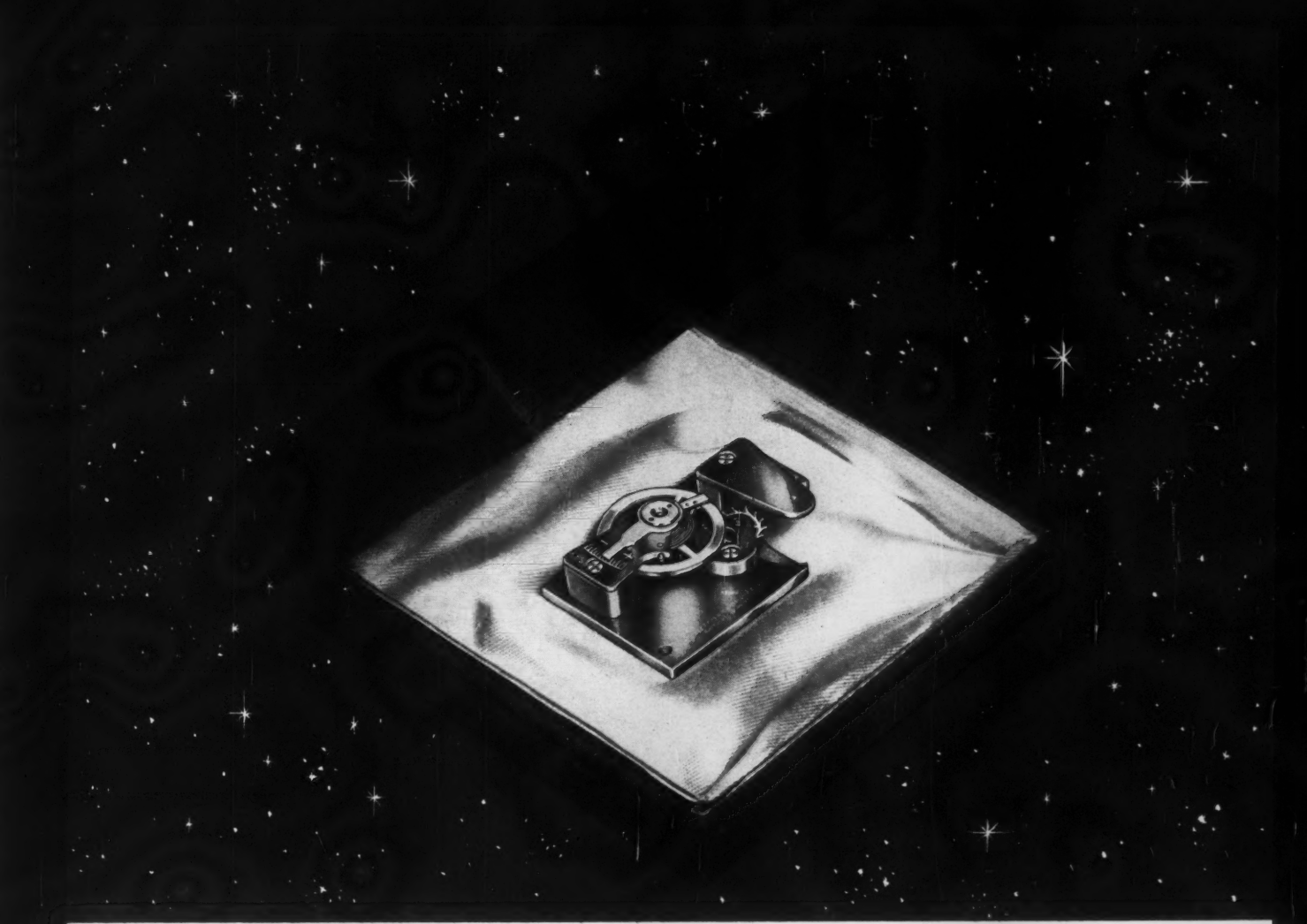
The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 40 ON READER-SERVICE CARD



This "jeweled" escapement brings you fine watch quality in chart drives

See how easy it is to convert to seven different rotation rates

The main arbor on the basic chart drive has a rotation rate of seven days. Economical snap on turrets convert this rate to 8 day, 15 day, 16 day, 24 day, 30 day, 31 day and 24 hour rotation. No tools are required and you can even change chart rotation without removing the drive from the instrument.

Now, for the first time you get the extra value of a jeweled movement. This superior construction makes Rockwell chart drives more accurate and sensitive than ordinary chart drives. It requires less power to drive and is extremely durable since there are seven hard jeweled surfaces to overcome friction and wear.

You can use these jeweled movement chart drives *with profit* to power all your recording instruments. They will adapt into practically any instrument case. Speed changing turrets (see left) permit varying rotation rates at will. Write for bulletin. Rockwell Manufacturing Company, Dept. 58-F, Pittsburgh 8, Pa. In Canada, Rockwell Manufacturing Company of Canada, Ltd., P.O. Box 420, Guelph, Ontario.

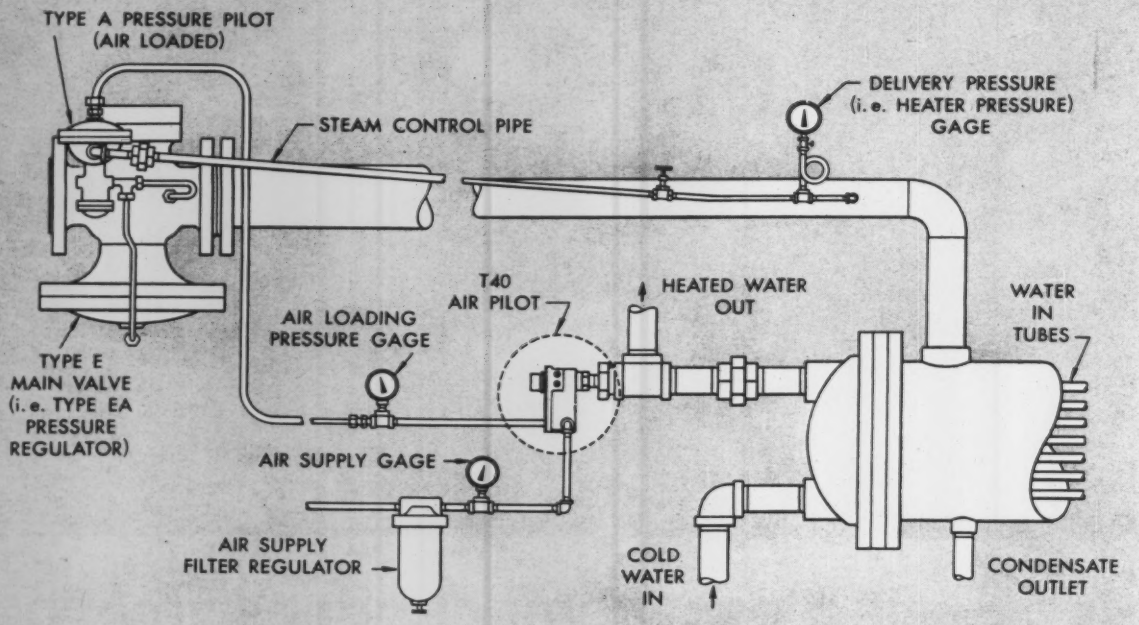
JEWELED CHART DRIVES

another fine product by

ROCKWELL

CIRCLE 41 ON READER-SERVICE CARD

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i.e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i.e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

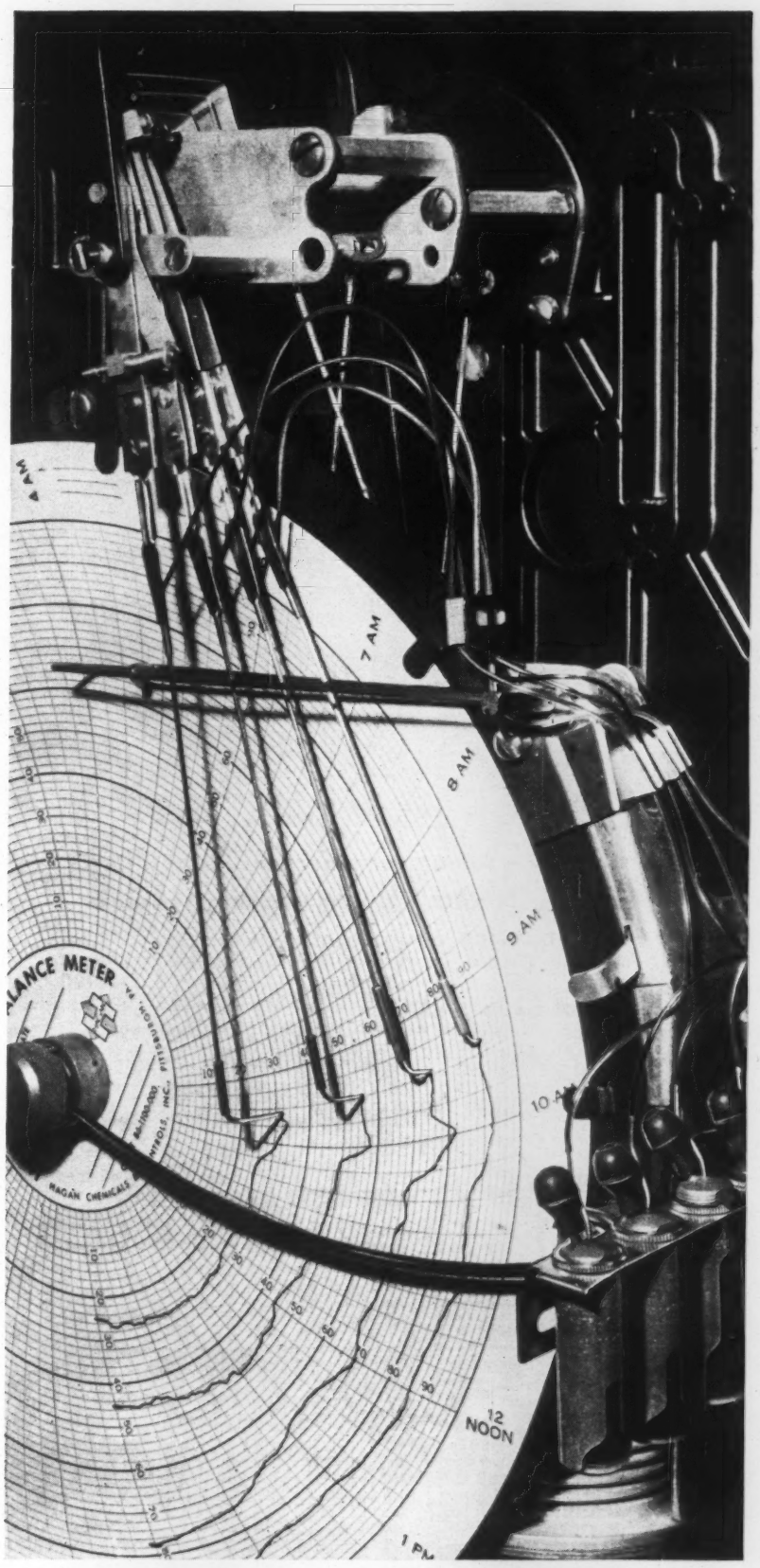
Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden 1, New York

SE-149A

CIRCLE 42 ON READER-SERVICE CARD



Esterbrook's new "Meter Marker" system cuts service costs to the bone

You give your customers *three* important money-saving, time-saving benefits when you equip meters you make with Esterbrook's new meter marking systems.

1. Ink cartridge convenience—Only Esterbrook's new meter marking system feeds from a king-sized "Slip-in" ink cartridge. Eliminates suction tubes, syringes and ink droppers. Cartridges replace instantly, hold enough ink for several months of use. *Result:* Minimum service.

2. Won't flood, clog, or fail to write because dirt can't get in. Esterbrook's ink cartridge is sealed until punctured by the ink-feed capillary tube. The pen-tip is precision-polished to prevent the picking up of paper particles which could plug it. *Result:* Minimum maintenance.

3. It's custom-designed and built (not jury-rigged) for *your* product by Esterbrook's expert Technical Products and Instrument Division—for any type recorder . . . circular, strip, miniature *or* plotter. *Result:* Long life . . . trouble-free performance.

THOROUGHLY FIELD-TESTED
by engineers of these leading companies:

• **Mobil Oil** (Paulsboro Refinery) • **Owen-Corning Fiberglass Corp.** (Barrington, N. J. Plant) • **The Alan Wood Steel Company** Conshohocken, Pa. • The Brewery operated by **C. Schmidt & Sons, Inc.** Philadelphia, Pa. • **The Philadelphia Suburban Water Co.** Bryn Mawr, Pa.

Let us tell you more about it. Satisfaction is guaranteed. Write:

ESTERBROOK
PEN COMPANY
TECHNICAL PRODUCTS AND INSTRUMENT DIVISION, CAMDEN 1, NEW JERSEY

NAME_____

COMPANY_____

Manufacturer ( ) Consumer ( )
Instruments manufactured or used?

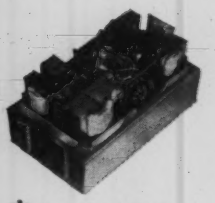
_____

*Number in use?*_____

CIRCLE 43 ON READER-SERVICE CARD

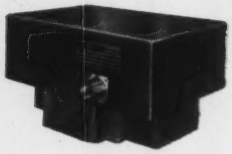
NAME THE CHARACTERISTICS* YOU WANT IN STATIC POWER

* Large Overload Capacity: 200%

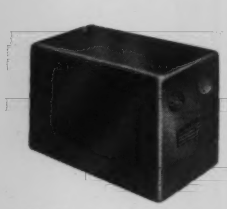


* Low Power Factor: 0.3 lagging to unity

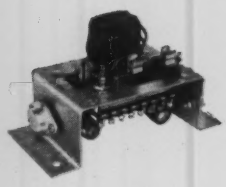
* Dual Output: Single or Three Phase



* Wide Temperature Range: −55° C to +125° C

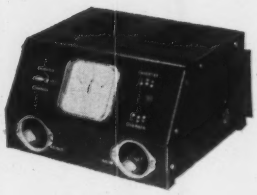


* Accurate Frequency Regulation: 400cps. ± 0.25%



* High Efficiency: 85% minimum

* High Voltage Output: 150 KV



* Dual-Purpose: Charger and Inverter

...for • industrial telemetry systems • remote or emergency signalling, warning or measuring systems • automated machine tools • microwave communication equipment

... wherever circuit interruption cannot be tolerated

You probably would not need all of the design/performance characteristics listed above in a single inverter. But today, after a three-year, full-scale development program, Hamilton Standard static inverters offer a wider range of proven design and operating characteristics than any you can buy—individually and in combinations. This means that Hamilton Standard static inverters can deliver the extra reliability, long maintenance-free service and quick starts heretofore unattainable with rotary power supplies.

If your equipment calls for a power supply with exceptional reliability, tell us about your complete requirements. We can provide the inverter you need.

What are inverters ... how, when and where to use them. A comprehensive aid for engineers. For your copy, write: Hamilton Standard Electronics, Broad Brook, Conn.

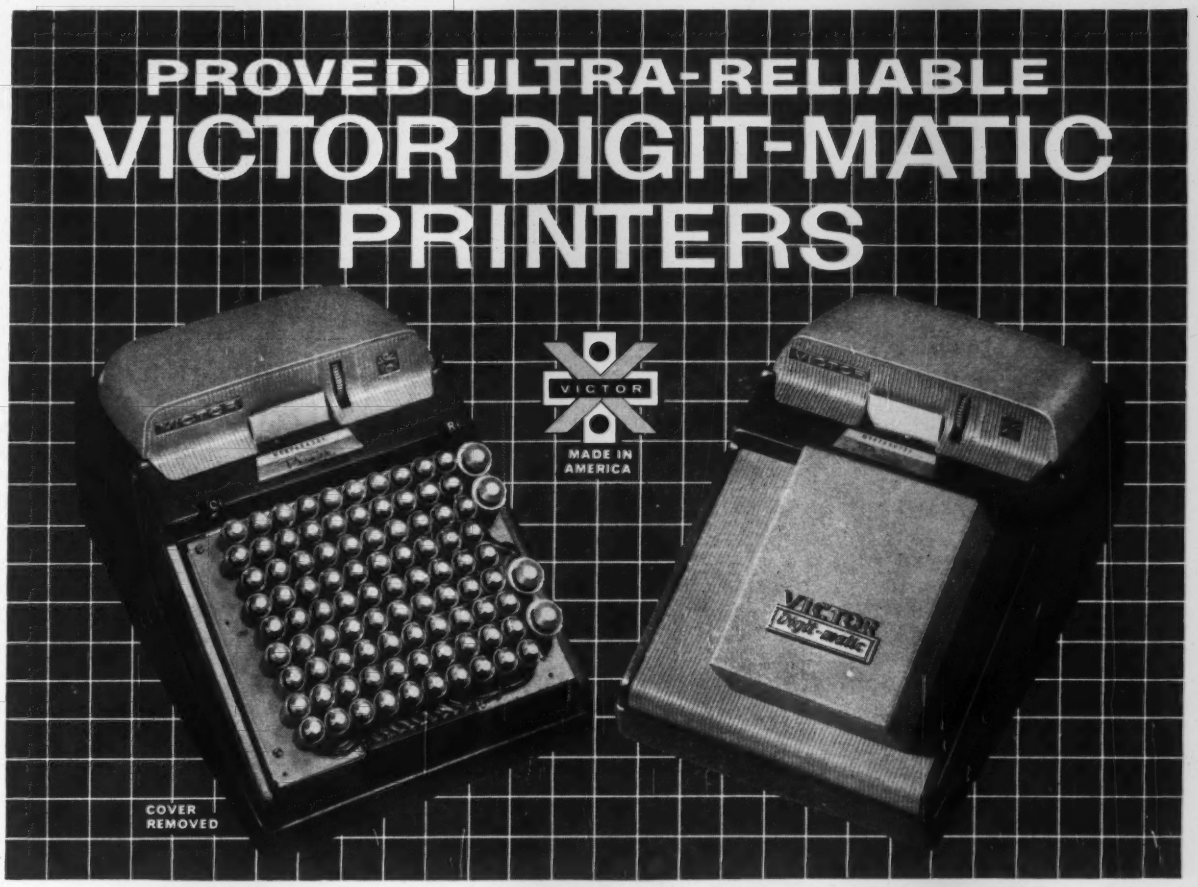
UNITED AIRCRAFT CORPORATION

HAMILTON STANDARD DIVISION

ELECTRONICS

CIRCLE 44 ON READER-SERVICE CARD

PROVED ULTRA-RELIABLE VICTOR DIGIT-MATIC PRINTERS



160,000,000 digit impressions without failure

Rugged, Trouble-Free—Digit-Matics are specially built to stand the strain of continuous operation. In a durability test, over 160 million digit impressions were made without breakdown or need of adjustment. The machine tested operated continuously, eight hours per day until 160 million digit impressions were made. During this period only normal lubrication and cleaning were performed.

Parallel or Serial Entry — Automatic and unattended, solenoid-activated Digit-Matics print out alpha-numeric data from remote equipment. High speed parallel entry models accept up to 10 digits at a time, print up to 4 lines per second. Serial entry models accept 1 digit at a time, up to 11 per line.

Two-Color Printing — Positive values in black, negative values in red. Ideal for "accept-reject" sequences, testing applications, accumulating data from two sources on one Digit-Matic, and many other uses.

Adaptable to Your Specific Needs — Line includes listers, accumulators and calculators. Versatile units can handle degrees, minutes, seconds, fractions. Other modifications: superimposed keyboard for manual use, time readings, counters, etc.

Immediate Field Service — 70 factory service branches and service representatives in over 600 cities assure uninterrupted operation. Victor offers 30-day delivery on most Digit-Matics. Mail coupon now for product data and application information.

VICTOR
ELECTRONICS DIVISION

Victor Adding Machine Co., Chicago 18, Illinois
Victor Adding Machine Co., (Canada) Ltd., Galt, Ont.

Manufacturers of Digit-Matic Printers, Scanning Printers, Electrical Keyboards, and Digit-Matic Data Punches

ICS-6

Victor Adding Machine Co.
Chicago 18, Illinois
Send full information on Victor Digit-Matics.

My application is_____

Name_____ Title_____

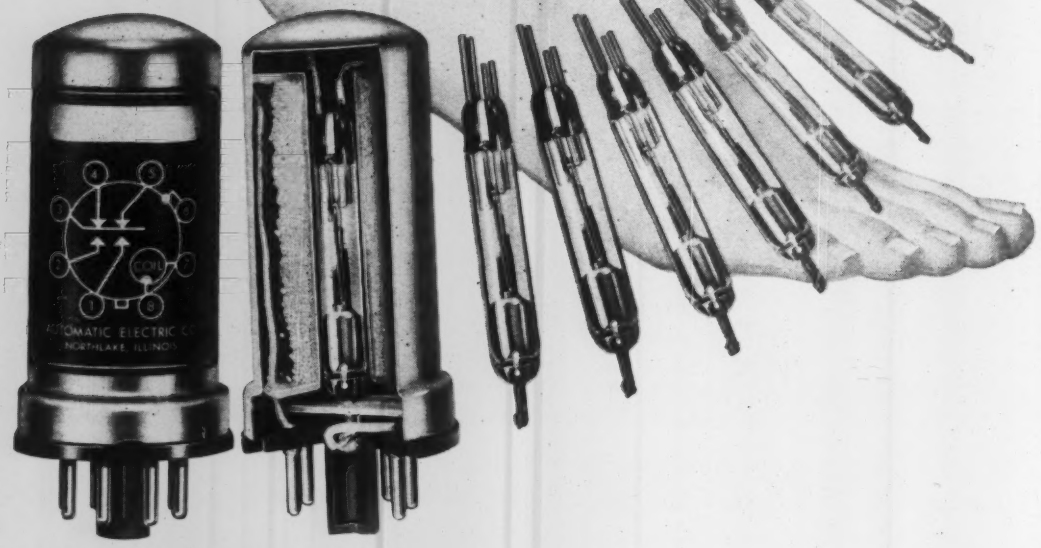
Company_____

Address_____

City_____ State_____

CIRCLE 45 ON READER-SERVICE CARD

AE



TO THE ENGINEER

who needs the magic of mercury

If you're stymied by switching problems in data processing, automatic control or high-speed keying, then consider the unusual attributes of AE's Series V51 mercury-wetted contact relay.

This fleet switcher can be driven at speeds up to 100 operations per second, completely free from contact bounce. It requires no maintenance within its life of over a billion transfers. The contacts can switch dry circuits or handle loads up to 250 volt-amperes. Operate and release time is approximately 3 milliseconds.

Contact and armature assemblies of the V51 are hermetically sealed in a glass capsule with a high-pressure hydrogen atmosphere. Mercury wetting continuously renews the contacts, eliminates wear, erosion, welding and sticking. Operating sensitivity is 250 milliwatts, minimum.

AE engineers will be glad to aid in applying the V51 to your designs. Ask for Circular 1988 covering full specs on the V51. Write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 46 ON READER-SERVICE CARD

NO STEPPING SWITCHES IN THIS ULTRA-RELIABLE DVM:

Cubic announces a new digital voltmeter design that eliminates stepping switches and, with them, the need for periodic maintenance. The new Cubic V-70 uses the same ultra-reliable reed relays developed for submarine cables. These reed relays are sealed in glass and have practically unlimited life. They are noiseless and completely unaffected by operating position.

Accurate: The V-70 reads any d-c voltage from 0.001 to 999.9 volts with an absolute accuracy of 0.01% plus or minus 1 digit. The Cubic V-70 Digital Voltmeter provides these and other premium features at a cost of only $1,580. For details, write to Dept. IC-105, Industrial Division, Cubic Corporation, San Diego 11, Calif. (in Europe: Cubic Europa S.p.A., Via Archimede 185, Rome).

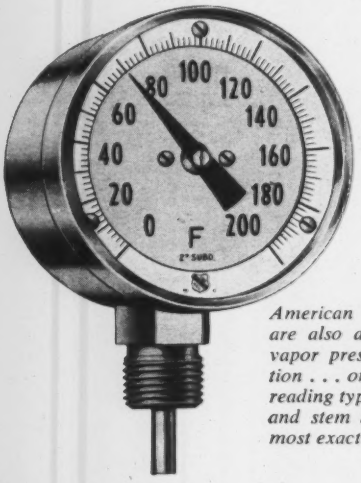
Cubic manufactures a complete line of quality digital instruments, including a-c and d-c voltmeters, ohmmeters, ratiometers, scanners and printer controls.

cubic CORPORATION
INDUSTRIAL DIVISION
SAN DIEGO, CALIF., U.S.A. ROME, ITALY

CIRCLE 47 ON READER-SERVICE CARD

sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points



American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 155.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

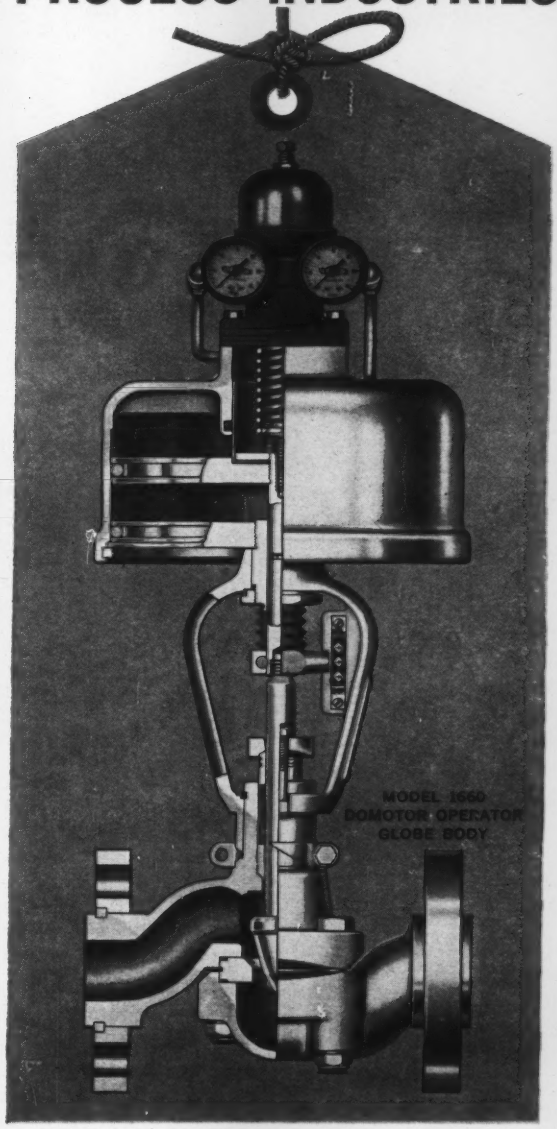
MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

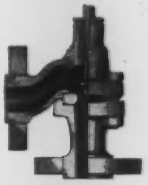
Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 48 ON READER-SERVICE CARD

WHY ANNIN IS A LEADING SUPPLIER OF CONTROL VALVES TO THE PROCESS INDUSTRIES

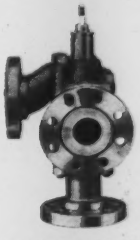


Annin control valves have been designed with the needs of the process industries in mind. The split body, single seat construction reduces body turbulence and erosion, gives longer life. The interchangeability of Annin valve components, the easily replaceable trim, the option of angle or 3-way bodies carried in stock for immediate shipment, simplifies your installation and maintenance problems. The flexibility in basic design cuts down on the valve parts inventory ordinarily required for a variety of plant applications. Another factor is the $1½ million in alloy body parts regularly carried in Annin stock, including a wide range of 300 series stainless steels, Hastelloys, Monel, Inconel, Durimet-20, and a variety of bronzes. If reduced valve inventory, design flexibility, and economical maintenance are factors in your operation, we suggest you investigate the advantages inherent in Annin process control valves.



ANGLE BODY

For fluid problems involving solids in suspension, high viscosity fluids, and applications requiring special nozzle materials or design.



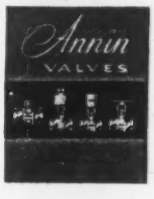
3-WAY BODY

Provides two horizontal line connections and an individual bottom vertical line connection. Sections may be rotated for convenience.

CORNER BODY

Standard for body sizes ½"–2". Often used to replace expensive alloy ells, this body simplifies installation and conversion on the job.

ANNIN DESIGN FLEXIBILITY reduces inventory...simplifies installation and maintenance...as no other control valve can!



ANNIN VALVES

Products that work for your profit.

Send today for General Catalog 1500-E

THE ANNIN COMPANY
1040 S. Vail Avenue • Montebello, California

CIRCLE 49 ON READER-SERVICE CARD

Burner flame on?

New FLĀMON Detector

can help you be sure!

Two FLĀMON Detectors installed for independent monitoring of main burner flame and pilot flame of a gas-fired boiler.

Properly installed, the FLĀMON Detector *responds only to the flame it surveys.* Glowing refractories—or flames from adjacent burners—do not produce false signals. Positive monitoring of each burner is assured. Absence or failure of flame is sensed and accurately signaled—and transmitted to control auxiliaries—without use of external relays or amplifiers.

Key to automation . . . the FLĀMON Detector provides the key to reliable automatic light-off and shutdown.

Provides wide temperature range . . . the FLĀMON Detector can be used in ambient temperatures from −20 to 150°F. Flame-sensing element withstands temperatures up to 500°F.

Allows easy inspection . . . quick-disconnect, keyhole mounting simplifies checking of lens condition and detector alignment.

Simple, solid-state circuitry . . . the FLĀMON Detector unit contains only 10 components.

Weatherproof construction . . . design of Bailey unit makes it suitable for outdoor installation.

Your local Bailey Engineer can give you a demonstration of the FLĀMON Detector. Call him, or write Cleveland.

A 162-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 60 ON READER-SERVICE CARD

NOW
THE FAMOUS "NO MAINTENANCE" PRESSURE REDUCING VALVE WITH NEW STEEL BODY

The Leslie GP-type pressure reducing valves are recognized as the simplest, most rugged, most maintenance-free ever made. Sold under Leslie's famous 3-year no-maintenance guarantee, they have so far been available with cast iron or cast bronze bodies only.

To satisfy the heavy demand for GP performance and construction features in 150, 300 and 600 lb. steel-body valves, here is the new Class GPS valve in carbon steel and alloy steels for steam, air, gas and other vapors.

The design still uses only two moving parts—a Spiroflex diaphragm and the main valve. These are virtually indestructible. There is nothing to wear out.

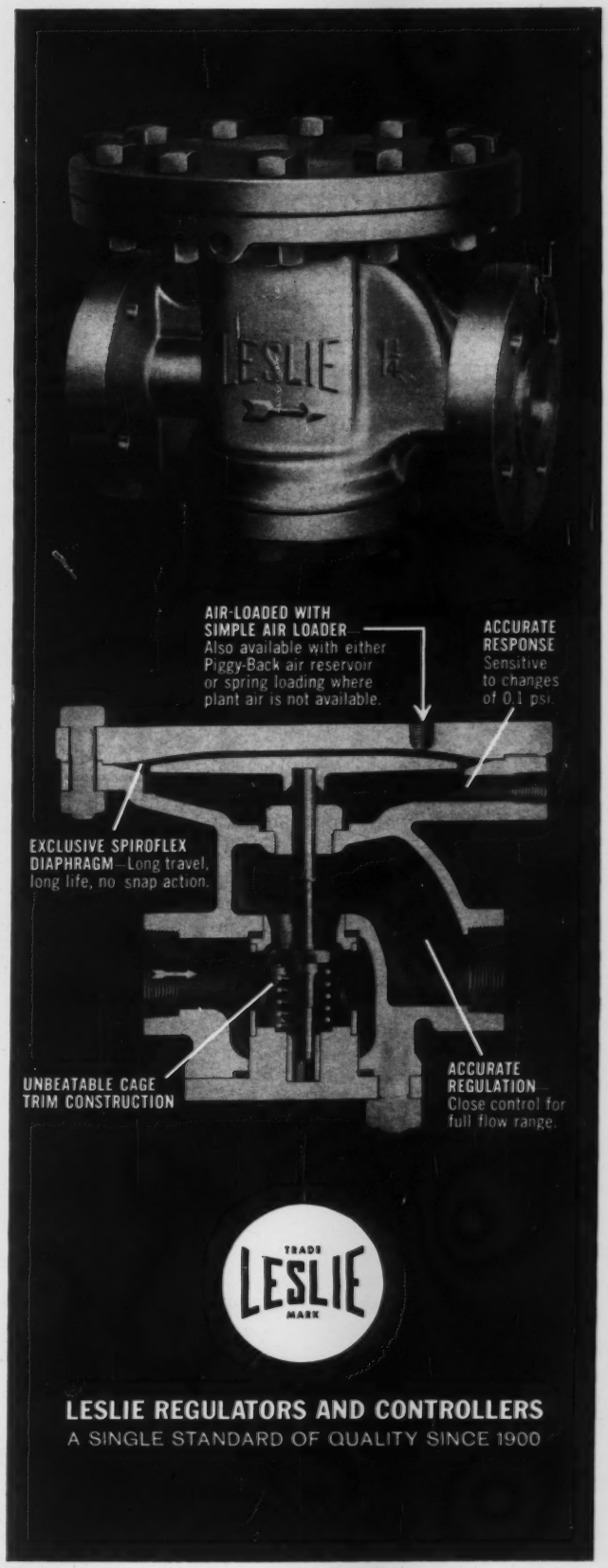
The low-stress diaphragm is the patented Leslie-Spiroflex®, which flexes like rubber but resists temperature as only a metal diaphragm can. Look at the cage trim construction—proved in Leslie-Lifetime control valves. Hardened stainless steel main valves seat on easily renewable, "permanent" type, stellited seat inserts. An unbeatable combination for long, trouble-free life.

The man to show you how much money this design will save you is your nearest Leslie Engineer. He is listed in the Yellow Pages under "Valves" or "Regulators." You will also want to send for our Product Data Sheet No. 611.

SPECIFICATIONS—Reducing Valve, GPS Classes

Sizes: ½" to 2" screwed or welding ends, or 150 lb., 300 lb. and 600 lb. flanges in carbon steel and alloy steels. Inquire about 2½ to 4" sizes soon to be available.
Diaphragm: Leslie-Spiroflex®, Stainless Steel.
Main Valve: Type 440C Stainless Steel, hardened.
Seat Ring: Stainless Steel, Stellited.
Stem Guides: Gun Metal Bronze (top and bottom guided).
Main Valve Spring: Inconel.
Inlet Pressure Range: 600 psi, 600°F.
Reduced Pressure Range: 0-300 psig.
Minimum Pressure Drop across Valve: ½ psi.

Leslie Co., 704 Grant Ave., Lyndhurst, New Jersey


LESLIE
AIR-LOADED WITH SIMPLE AIR LOADER—Also available with either Piggy-Back air reservoir or spring loading where plant air is not available.
ACCURATE RESPONSE Sensitive to changes of 0.1 psi.
EXCLUSIVE SPIROFLEX DIAPHRAGM—Long travel, long life, no snap action.
UNBEATABLE CAGE TRIM CONSTRUCTION
ACCURATE REGULATION—Close control for full flow range.
TRADE LESLIE MARK
LESLIE REGULATORS AND CONTROLLERS
A SINGLE STANDARD OF QUALITY SINCE 1900

L-43

CIRCLE 51 ON READER-SERVICE CARD

5 REASONS FOR SPECIFYING U.E. INDICATING TEMPERATURE CONTROLS

* **HIGH SENSITIVITY...** on-off differentials from ± .5° F with excellent repeatability

* **LOW COST . . .** list prices from $35.00 with generous quantity discounts

* **EASY MAINTENANCE . . .** thermal assemblies quickly replaced in the field with no loss of calibration accuracy

* **PROVEN DEPENDABILITY...** reliable liquid-filled measuring systems combined with simple service-proven components for accurate performance and long life

* **GREATER VERSATILITY...** many styles, ranges, sensing elements and switch characteristics permit hundreds of "custom-built" combinations

ALL PURPOSE

-150° to +650° F

A sensitive wide range unit with control point accuracy equivalent to individually calibrated instruments. 10" rotating scale permits unusual readability and close settings. Available with dual switches for controlling two independent circuits.

E 32N

E 36N

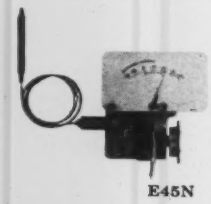
LOW COST... (800 Series) -150° to +650° F
Short dial spans of 50 to 200° F permit compact design only slightly higher in price than non-indicating controls. Available with dual switches.

HIGH TEMPERATURE . . . (900 Series) 0° to +1000°F
A NEW high temperature series with rugged stainless steel mercury filled thermal systems.

For the USUAL or UNUSUAL application, United Electric offers quality controls at economical prices.

E 65N

SPACE SAVING . . . -150° to +650° F
Skeleton design permits direct incorporation into equipment – saving cost of enclosure. Many models with dial spans of 50 to 200°F. Available with face plate for panel mounting.



E45N

SPECIAL PURPOSE . . . -150° to +1000°F
Shown here is a typical Special Purpose control used on medical equipment, such as baby incubators, etc. WHAT IS YOUR REQUIREMENT? Chances are one of our standard controls will satisfy your needs. If not, we'll put our 30 years' experience to work for you on special designs.

UNITED ELECTRIC CONTROLS CO.
85 School Street
Watertown 72, Massachusetts
SUBSIDIARIES
United Electrical Controls (Canada) Ltd. | United Sensor & Control Corp.
O'Connell Avenue Dorval, Quebec | Box 149 Glastonbury, Conn.

Write TODAY for complete specifications and price information on U. E. Indicating Temperature Controls, Attention Dept. W.

NAME_____ TITLE_____

COMPANY_____

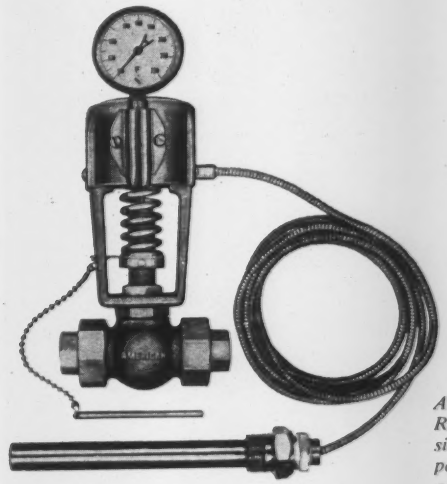
ADDRESS_____

CITY_____ STATE_____

CIRCLE 52 ON READER-SERVICE CARD

immediate

AMERICAN TEMPERATURE REGULATORS begin corrective action with less than 1/10 degree change at the bulb



American Temperature Regulators are made in sizes ½" to 4". Temperature ranges as low as minus 15° F. to 50° F.—as high as 240° F. to 350° F.

response

You get fastest possible temperature response from these new regulators because the stem cannot bind and retard valve action.

The valve stem on American Temperature Regulators is sealed off by a friction-free bellows that makes practical a nonleaking packless valve. Also contributing to fast, stable action is the use of an extra-long preflexed adjusting spring. This spring permits a long range of temperature adjustment without disturbing valve sensitivity at normal levels.

There are other high-quality features in American Temperature Regulators: maximum use of stainless steel; standardized parts; the fewest possible components; and unitized assembly. In addition, compactness simplifies installation in "tight" locations.

Accurate temperature regulation and attention-free operation mean long-term economy. Your industrial supply distributor will gladly help you select the right American Temperature Regulators for your needs. Write for Bulletin 114C.

MANNING MAXWELL & MOORE INC. MM&M TRADE MARK

AMERICAN TEMPERATURE REGULATORS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

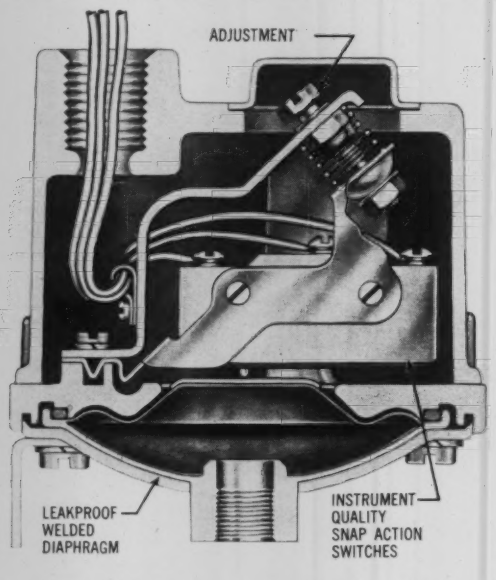
Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 53 ON READER-SERVICE CARD

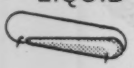
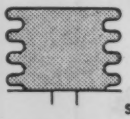
BREAKTHROUGH IN PRESSURE SWITCH ACCURACY

at reduced prices

The high accuracy associated with instruments costing several hundred dollars is now obtainable with new Barksdale pressure switches at a retail cost of $19.00 to $30.00. Accuracy of ±0.5% is guaranteed and ±0.2% accuracy can be supplied when required. Substantial price reduction is accomplished by use of erector set design and a major investment in production tooling. A wide choice of "tailored to the job" features (see column at right) meets your specification requirements exactly.



THESE POINTS ARE IMPORTANT

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	 LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	 ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

New line of Barksdale pressure switches announced

Improved accuracy, reduced cost and higher proof pressures are advantages made possible by design innovations in the new Barksdale diaphragm pressure switches. Accuracy of ±0.5% as compared to the customary ±1.0% is guaranteed, and each unit is tested for repeat accuracy of set point and re-set point before shipment. Accuracies of ±0.2% are available on request.

Erector set design offers dual benefit

The basic unit of all Barksdale diaphragm pressure switches is a diaphragm surrounded by a heavy protective capsule to which components may be attached as required. Addition of a switch, switch bracket and adjusting bracket to the basic unit makes a stripped switch for use in a common cabinet with other electrical devices. (Original equipment manufacturers need not pay for a housing which is not needed.) Addition of a sealed housing to the stripped switch completes a weather- and vapor-tight switch unit. A standard housing with integral terminal block or an explosion proof housing with integral terminal block may be specified. Erector set construction allows a wide choice in specifications that approximates a custom made switch and permits use of cost-cutting mass production methods that are reflected in lower prices.

Proof pressures to 600 psi

In the low settings the new Barksdale pressure switches will actuate at 0.1" mercury with proof pressure to 10 psi. In higher ranges they will go up to 600 psi proof pressure at settings to 400 psi. This makes it possible to use inexpensive diaphragm pressure switches on installations that presently require higher priced bourdon tube switches.

Important additional advantages

Because the housings of Barksdale pressure switches are independent of the sensing and switching mechanisms changes in ambient temperature will not throw these switches out of adjustment.

The adjustment brackets are specially designed to protect switch terminals against shorting during adjustment.

Lead wires are held down by a tension clip. They cannot be pulled out accidently and thereby throw off the switch adjustment.

Mounting brackets may be oriented in any of four directions.

Tamper proof adjustment covers have servicing instructions on the inside to allow for painting of the units.

Standard pressure connection is ¼" n.p.t. female pipe fitting. One-half inch fittings suitable for mounting directly on ½" pipe can be supplied on request.

Standard housing has ½" nps conduit connections and a terminal block. The latter is accessible without removing the housing by lifting a cover plate.

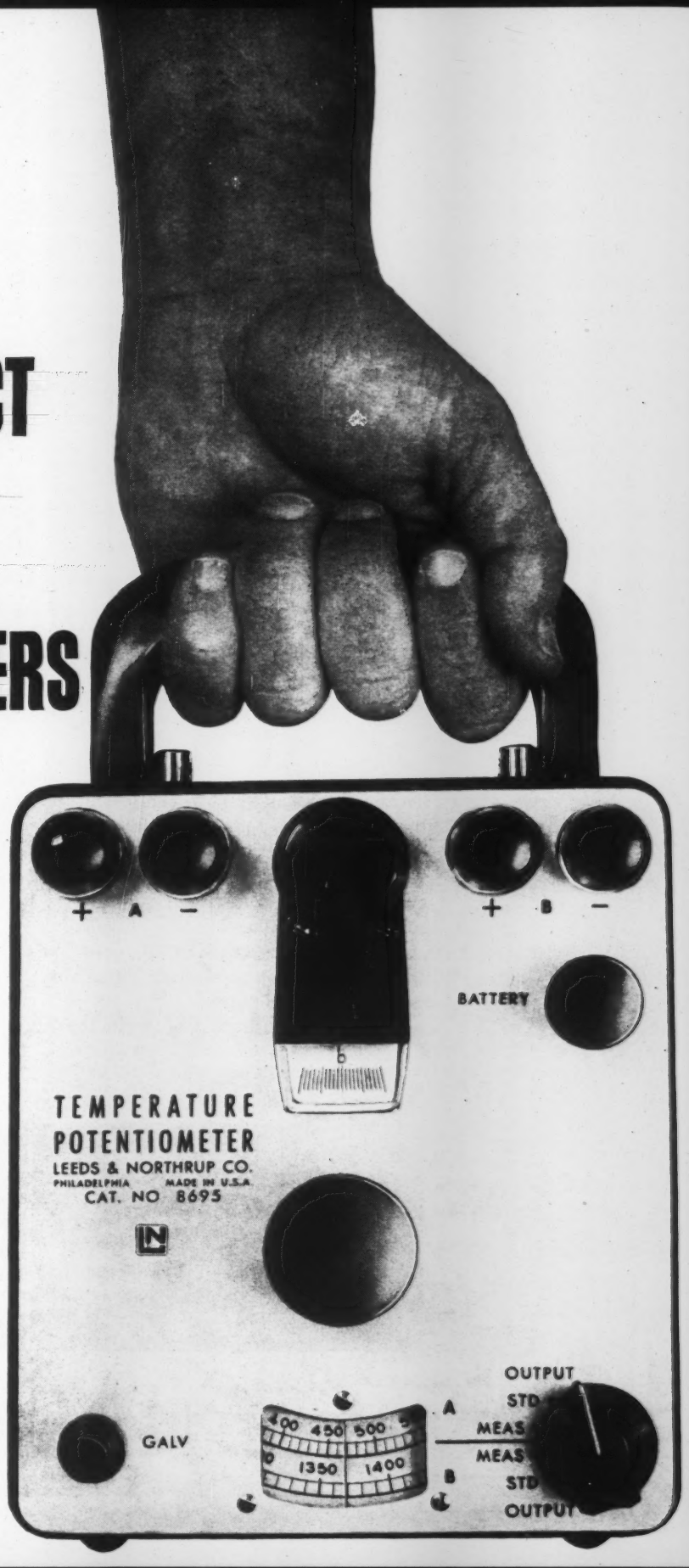
Ask for new catalog and handbook

Complete details on Barksdale diaphragm, piston and bourdon tube pressure switches are included in a new catalog and handbook. This free book is a practical aid in planning the vital link between your electric and hydraulic circuits. It contains a glossary of terms, a schematic demonstration of operating characteristics, and a suggested step-by-step procedure for simplifying pressure switch selection. In addition, the book gives a complete run-down on all the detail features leading to the unit that answers your specific control problems. Send for your copy now, or ask your Barksdale representative.

CIRCLE 54 ON READER-SERVICE CARD

CIRCLE 55 ON READER-SERVICE CARD →

NEW, COMPACT LOW COST L&N PORTABLE POTENTIOMETERS



If you check thermocouples, recorders or controllers in plant or lab and are tired of lugging around an oversize instrument just to get the precision you need, you'll welcome one of L&N's three new portable—*really* portable—potentiometers. All the essentials—galvanometer, battery, standard cell—are compactly housed in a 7″ x 6″ x 5″ case . . . and weigh only 4½ pounds. An 8694 Single-Range and an 8695 Double-Range Potentiometer read directly in degrees in any of 15 temperature ranges. An 8696 Potentiometer reads directly in millivolts on two ranges, 0 to 22 and 20 to 64 . . . has a manual reference junction compensation dial, and can be used as a source of calibrated voltage for checking other potentiometer-type instruments.

Get the full story on these new compact instruments—*and* their compact price (starting at $200.00). Just phone your nearest L&N Office, or write for Data Sheet E-33(5) from Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

LEEDS & NORTHRUP

Pioneers in Precision

All here . . .

components that satisfy

all pressure/flow system needs

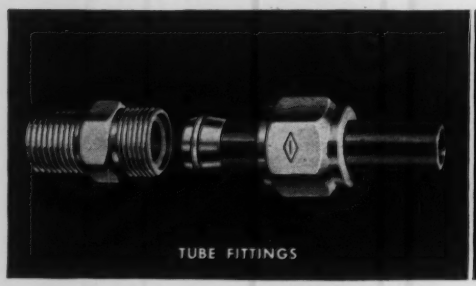
IMPERIAL EASTMAN

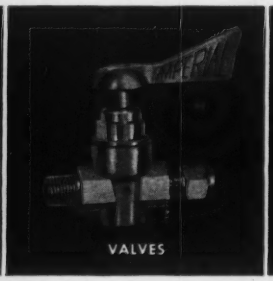
Now together, Imperial-Eastman meets all your hydraulic-pneumatic-flow component needs: tube fittings, valves, couplings, flexible and rigid hydraulic lines, thermoplastic tubing and tubing tools.

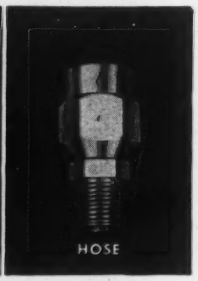
This *engineered* line gives you the exact product for every type of service condition—and the tools to make sure your assemblies are absolutely right.

For added satisfaction at your point of order, Imperial-Eastman products are available through highest caliber distributors.

For complete information, write for Catalog No. 101.


TUBE FITTINGS


VALVES


HOSE

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

CIRCLE 56 ON READER-SERVICE CARD

Only

IMPERIAL EASTMAN

offers a line as complete as this

When we say *your most complete line* of pressure flow system components for all hydraulic, pneumatic, instrumentation and other applications—here's what we mean:

TUBE FITTINGS OF EVERY TYPE AND SIZE—FOR ALL PRESSURES, TEMPERATURES

- Hi-Seal® Butt Joint Fittings, Braze-Seal Hi Pressure, Hi-Duty, 37° Flare, 45° Flare, Flareless, Flex, Compression, Inverted Flare, Threaded Sleeve and Plastic Tubing Fittings.

FLUID CONTROL VALVES

- Needle, Toggle, Diaphragm, Plug, Blow-Down and Kwik-Connect Types for pressures up to 5000 psi.

HOSE AND COUPLINGS

- Medium-Pressure Hose and Tube Assemblies, Couplings and Fittings for One-Wire Braid Hose
- High-Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple-Wire Braid Hose
- Low-Pressure Hose and Tube Assemblies, Couplings and Fittings for Fabric Braid Hose
- All Synthetic—for Pressures up to 3000 Lb.
- Adapter Unions, Adapters and Tube Fittings

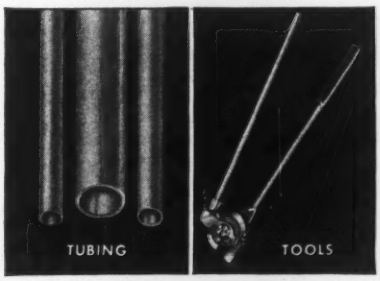
TUBING

- Plastic and Thermoplastic

TUBING TOOLS

- Cutting, Flaring, Bending, Reaming, Swaging, Pinch-off, Refacing Tools
- Service Aids

No doubt about it now—see your Imperial-Eastman distributor *first* for all hydraulic-pneumatic-flow system components.



IMPERIAL EASTMAN

Chicago 48, Illinois

IGS EVENTS

June 28-30
National IRE Convention on Military Electronics, Shoreham Hotel, Washington, D. C. For information write Charles DeVore, 3224-16 St. N.W., Washington 10, D. C.

June 28-30
Second Joint Automatic Control Conference, University of Colorado, Boulder, Colo. For information write Meetings Manager, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

June 26 to July 1
International Measurement Conference (IMEKO), Engineering Societies Building, Budapest, Hungary.

June 27-30
Second Technical Conference on Hurricanes, Barcelona Hotel, 4343 Collins Ave., Miami Beach, Fla. For information write Kenneth C. Spengler, American Meteorological Society, 45 Beacon St., Boston 8, Mass.

July 16-21
Fourth International Conference on Medical Electronics and Fourteenth Annual Conference on Electrical Techniques in Medicine and Biology, Waldorf-Astoria Hotel, New York, N. Y. For information write Lewis Winner, convention and exhibit manager, 152 W. 42nd St., New York 36, N. Y.

July 17
Exhibit of Temperature Measurement and Control Instrumentation, Institute of Aerospace Sciences, 7660 Beverly Blvd., Los Angeles, Calif. For information write L. H. Freeman, secretary, Temperature Measurements Society, 4063 Radford Ave., Studio City, Calif.

August 14-17
Ninth Annual Short Course in Fundamentals of Occupational Safety, Louisiana State University, Baton Rouge, La. For information write Fred H. Fenn, Dean, College of Engineering, Louisiana State University, Baton Rouge 3, La.

August 15-17
1961 Cryogenic Engineering Conference, University of Michigan, Ann Arbor, Mich. For information write K. D. Timmerhaus, Chemical Engineering Dept., University of Colorado, Boulder, Colo.

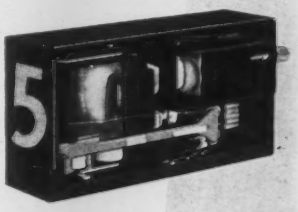
August 22-25
Western Electronics Show and Convention (WESCON), Cow Palace, San Francisco, Calif. For information write Don Larson, WESCON manager, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

August 28-30
21st Annual Appalachian Gas Measurement Short Course, West Virginia University, Morgantown, W. Va. For information write Prof. R. E. Hanna, University of West Virginia, Morgantown, W. Va.

BINARY OPERATED READOUT

New! Operates Direct—No Buffers or Translators Required

ALL DIGITS CAN BE READ FROM ANY ANGLE



BINA-VIEW Self-Decoding Alpha-Numeric Readout

Applications: Connected directly into computers, teletype, etc.

Features: Electro-magnetic operation, low power (10 milliwatts), accepts BCD code to 6 bits, does own translating.

Specifications: 1⅜" high character, module size 1¾" x 3¼" x 6¾"

Price Complete from $50.00

WRITE TODAY FOR COMPLETE DETAILED INFORMATION

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 VINELAND AVENUE
NORTH HOLLYWOOD, CALIF.
Representatives in principal cities.

CIRCLE 57 ON READER-SERVICE CARD

Ultra-fast Optics

for

INFRA-RED

Instrumentation

Reflective Optics

Cassegrain Systems

Paraboloids to f/.3

Off-axis mirrors

Refractive Optics

Si and Ge Optics

IR Windows

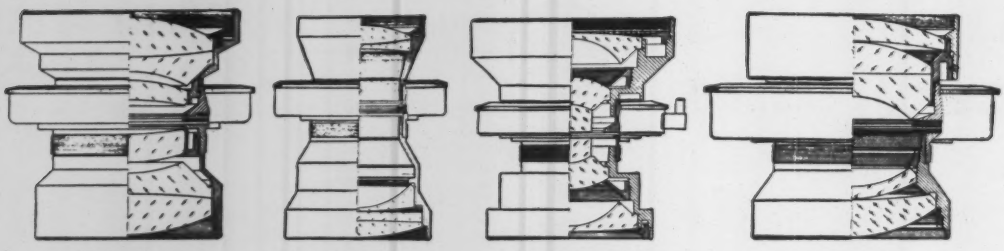
Aspherics

Mechanical Mountings

John Unertl Optical Co.

3551-55 East St.
Pittsburgh 14, Pa.

CIRCLE 58 ON READER-SERVICE CARD



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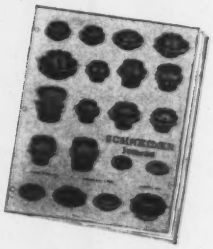

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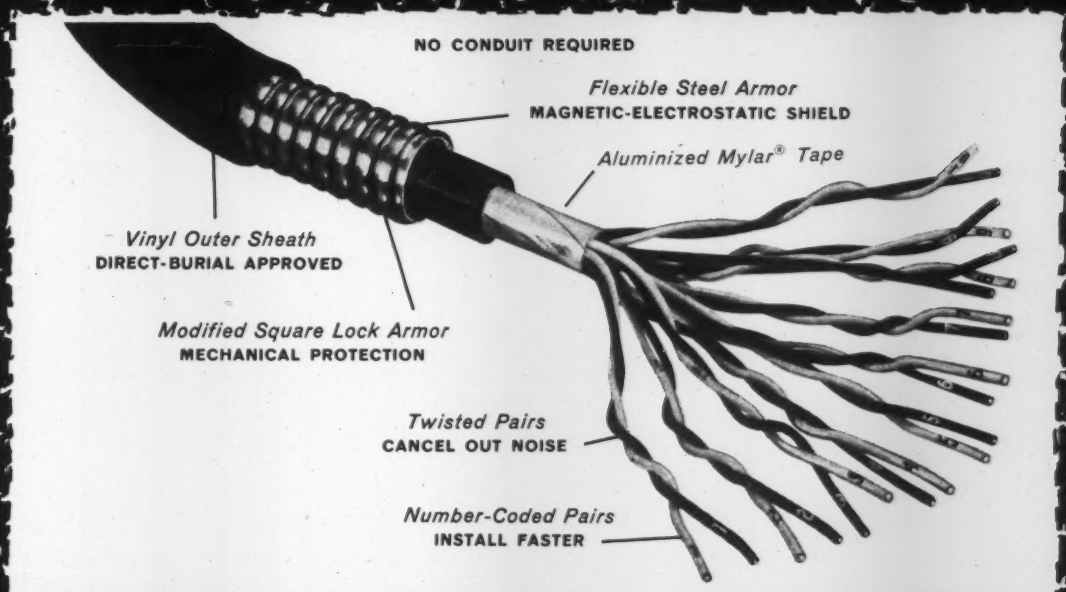
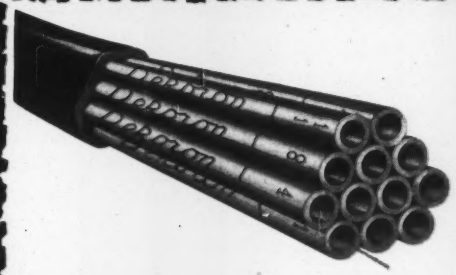
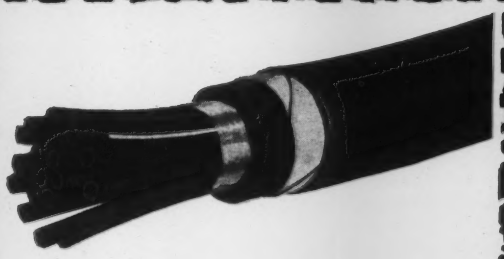




Dekoron New Metl-Cor combines exclusive parallel tubes of copper or aluminum with polyethylene protective sheath. Lack of "corkscrew effect" speeds installation. Dekoron also offers a full line of metal-armored tubing harnesses.



Dekoron Protecto-Pac (Type FB shown), an all-plastic harness with high resistance to weld splash, sparks, flash fires, etc. Dekoron Poly-Cor (not shown) has number-coded polyethylene tubes, Mylar® vapor barrier, flexible vinyl outer sheath.

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Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

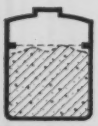

FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005″ and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

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*Viscosity may affect response time.

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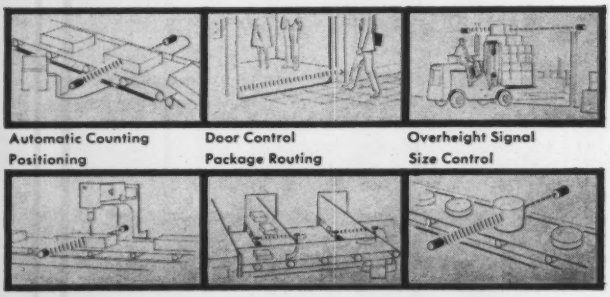

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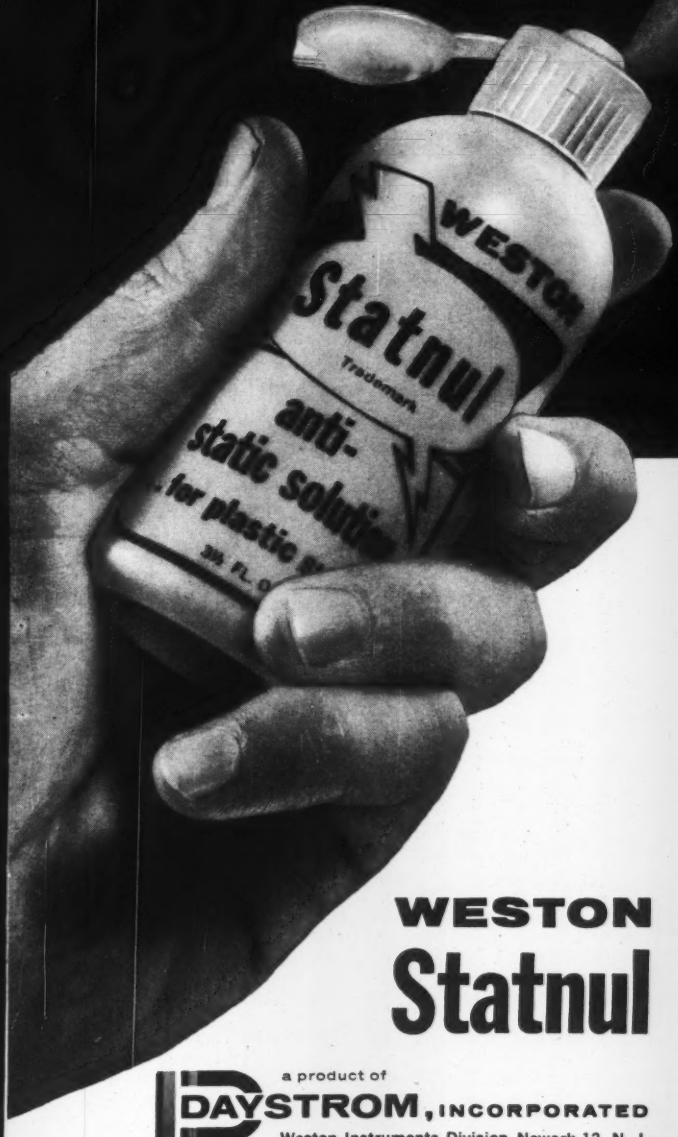

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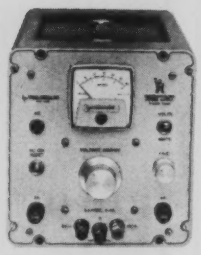

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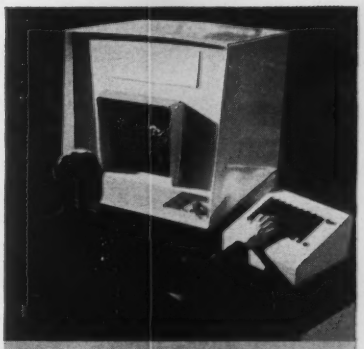
Technical	Term
Investigate pertinent design and operating factors for purposes such as feasibility of manufacture, availability of material and equipment, interchangeability and replaceability of parts, and functional performance of measurement and control components, subassemblies and assemblies, making full use of appropriate receptor and effector mechanisms.	Use your head, eyes, ears and hands.
Coordinate work with related work of other design, manufacturing, tooling, material, production, operation, planning, testing, standards, and related groups.	Get along with others.
Make judgements based on knowledge and experience regarding the practability and feasibility of proposed or operational systems and subsystems.	Don't repeat mistakes.
Use a systems approach to optimize complex interrelated variables and achieve maximum efficiency based on operational research techniques.	Fit the pieces together.
Review specifications with chief physicist or engineer, and jointly work out problems involving design and test of new instruments and systems.	Keep the long-hairs practical even if you do the work yourself.
Determine mechanical performance and chemical and physical characteristics of apparatus under actual and simulated operating conditions.	Test and calibrate item.
Suggest improvements in apparatus and methods and techniques for obtaining more valid tests or operations.	Guess what's wrong.
Initiate procedure changes to achieve greater efficiency.	Try something.
Design workable and practical instrument or system from rough drafts and written instructions, using knowledge of physics, thermodynamics, pneumatics, hydraulics, etc.	Be a good technician.
Analyze and summarize test data using knowledge of physics, algebra, trigonometry, and related mathematical techniques, including cross-correlation.	Make it mean something.
Maintain accurate records, prepare concise clear summaries of work, using good English grammar and composition, following basic principles of technical writing.	Let somebody know what you are doing.
Know all sources for locating general and specific technical data in order to extract and interpret information.	Read those magazines.
Formulate long-range implications of extensive technical programs involving prototypes, experimental models, or complex inter-related projects.	Make it look good, despite its cost.

"need to know now" applications of the RD-900 Random Access Storage and Display System.



The RD-900 provides a random access file of up to 495 million, or more, bits with access to information in less than 3/10 of a second. It is adaptable to virtually all existing computer systems, or may be used as an independent random access storage and display unit. The display device is a high resolution, flicker-free, 21″ direct view storage tube capable of exhibiting up to 12,800 characters or symbols. Alphanumerics, arbitrary or abstract symbols, graphs, charts and maps may be displayed.

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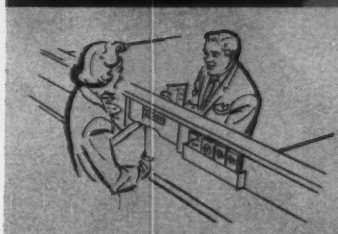
5. **Military Command Control** situations where a large volume of data must be digested and decisions based on such data must be reached within an extremely critical time period.



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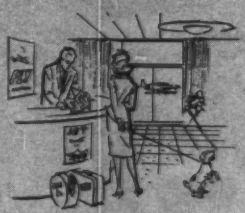

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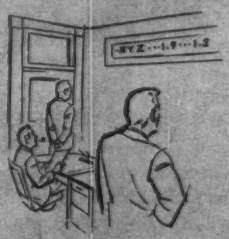

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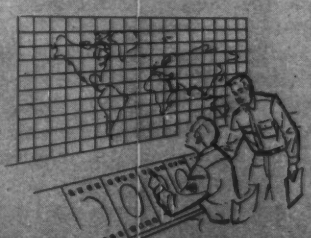

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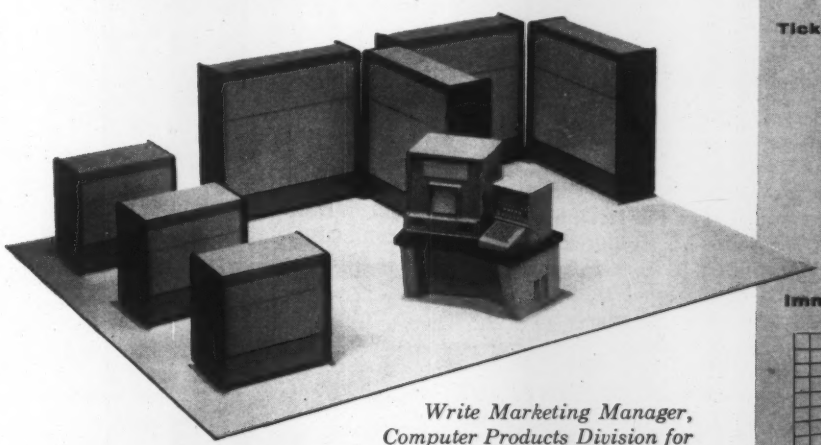

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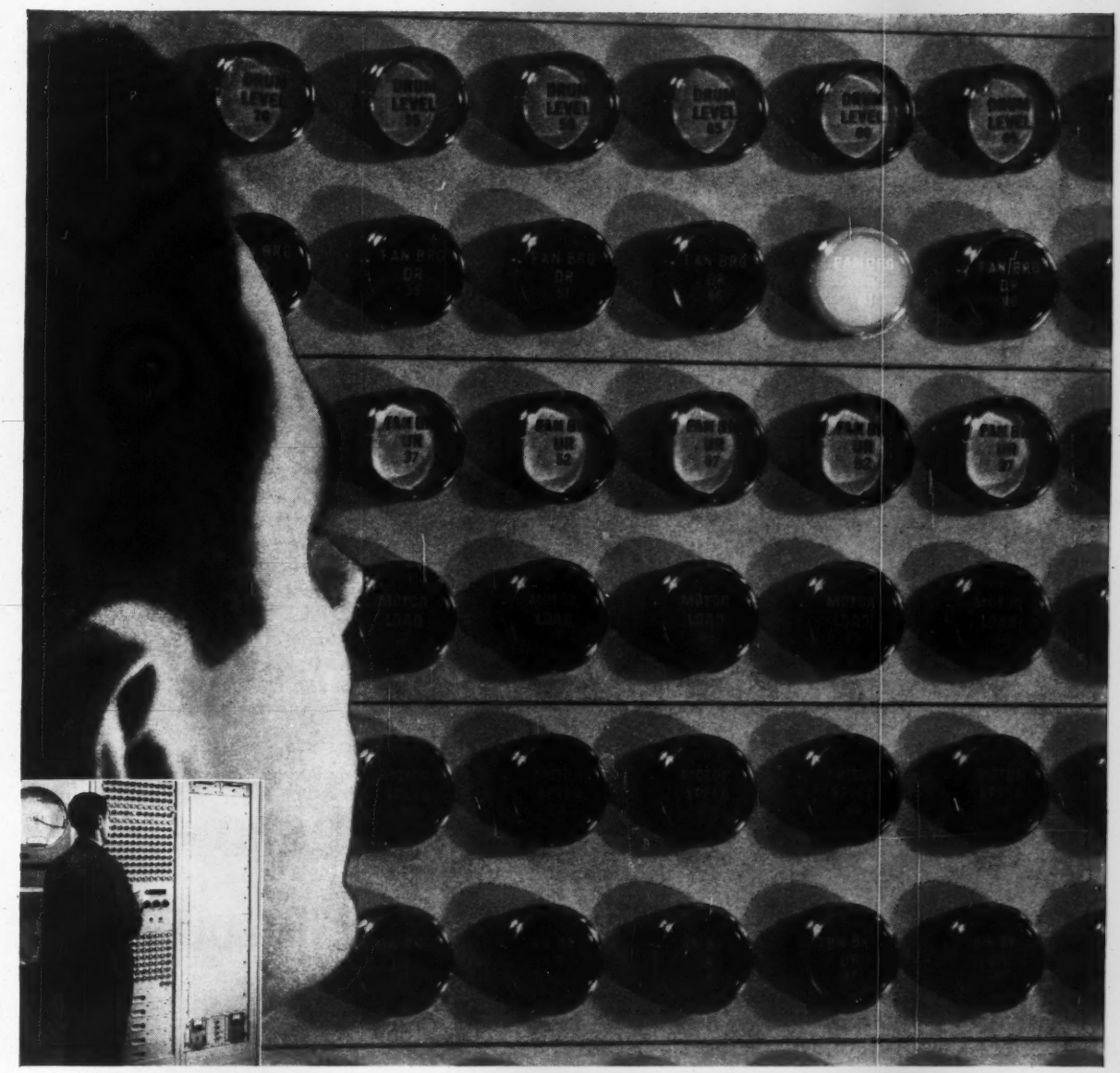

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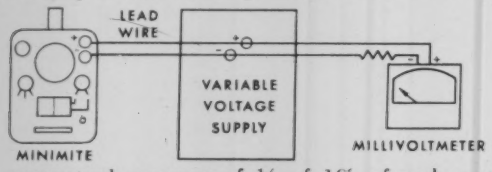
The MiniMite is a portable null-balanced potentiometer-type pyrometer indicator which provides laboratory precision in truly minute form . . . With

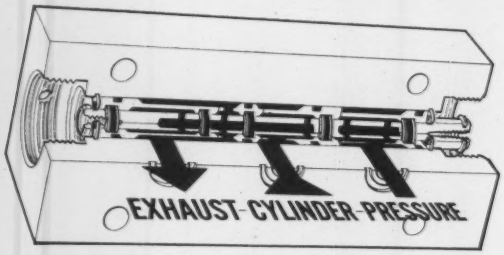


a guaranteed accuracy of ¼ of 1% of scale range . . . the instrument checks thermocouple calibration and may also be used for general temperature testing, laboratory work, emergency operation, and as a substitute for service instruments during repairs . . . The MiniMite is an accurately calibrated variable source of emf, and will precisely calibrate potentiometer-type instruments. When testing millivoltmeters, the MiniMite is used with an auxiliary current source, and is operated as a null-balance potentiometer . . . (*From new 4-page Bulletin Instrument Section* 64-1, *Thermo Electric Co., Inc., Saddle Brook, N. J.*)

FOR THIS LITERATURE CIRCLE 190 ON READER-SERVICE CARD

Spanseal Valves

Spanseal Control Valves are made up of three elements—basic valve, manifold block, and operating attachments. Basic valves are available in 4-



way, 3-way, 2-way, diverter and shuttle cycles. Standard attachments readily adapt to these basic valves. Attachments are available for pressure, solenoid, manual and cam operation. Attachments are interchangeable . . . In 2-way and 3-way valves, a normally closed cycle may be changed to normally open (and vice versa) simply by reversing the attachment positions on the basic valve. The types of attachments, or combinations of attachments, are selected by the user to fit a specific control application . . . (*From new* 8-*page Bulletin* 5000, *Ledeen, Inc.*, 3350 *No. Gilman Rd, El Monte, Calif.*)

FOR THIS LITERATURE CIRCLE 191 ON READER-SERVICE CARD

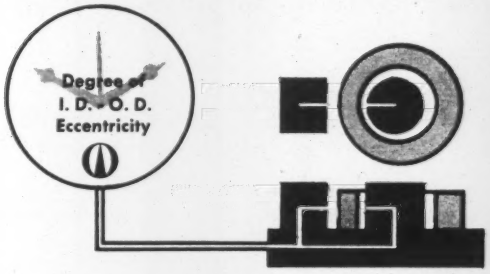
From Foxboro – the simplest pneumatic

Simplest to install

Foxboro's Type 12A Pneumatic Temperature Transmitter weighs just seven pounds and takes up as little space as your telephone. Installation is a one-man job. And look at the rugged mounting bracket. You can mount the Type 12A anywhere — in any position — even directly on the bulb well. You'll find it's easier to manipulate the new, smaller flexible armored tubing to just the spot you want. It won't kink either.

Air Gages

Standard Air Gage design is based on a proven unique pneumatic principle which features on-the-



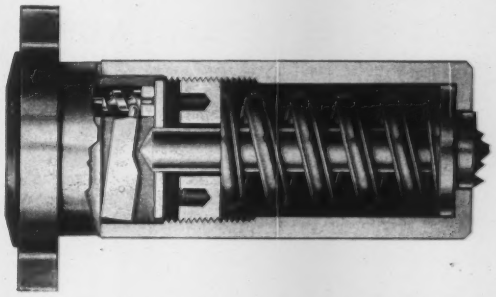
MANUAL ECCENTRICITY GAGE

job adjustable magnification . . . ("Adjustable Magnification" means that the dimensional value of the dial, from one end to the other, can be changed to suit any desired value within the specified range of the Gaging Stand . . . Adjustable magnification permits the use of a gaging member at any one of the several magnifications covering a wide range of full scale values and workpiece tolerance variations.) . . . Airplugs and Air-rings can be supplied to suit a wide variety of special applications . . . (*From new 32-page Catalog No. 61, Standard Gage Company, Inc., Poughkeepsie, N. Y.*)

FOR THIS LITERATURE CIRCLE 192 ON READER-SERVICE CARD

Hardness Testers

Webster Hardness Testers vary either in penetrator design or in the load spring itself, by which they can be adapted to testing a wide range of



hardnesses and metals . . . Gripping the handle depresses the entire penetrator assembly. Resistance of the work to the penetrator causes the penetrator to recede within the housing against the spring pressure. The load spring thereafter maintains a uniform force against the penetrator and toward the anvil, forming an impression upon any test piece gripped between the two members. Degree of penetration is indicated on the gauge . . . (*From new 6-page pocket-size folder, Webster Instrument, Inc., 11856 Mississippi Ave., Los Angeles 25, Calif.*)

FOR THIS LITERATURE CIRCLE 193 ON READER-SERVICE CARD

temperature transmitter ever

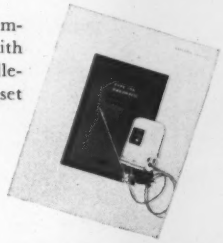
Simplest to calibrate

You can calibrate the Foxboro Type 12A Temperature Transmitter in the field in a matter of minutes. All you need is a screw driver for most span elevations. And for extreme elevations, you need just a simple compensator bellows. What's more, you get wider range limits to work with — from −400F to +1400F — and 15 spans.

Simplest to maintain

The Foxboro Type 12A Temperature Transmitter needs practically no maintenance. It has no links, no secondary levers or fulcrums. And it's fully compensated for ambient temperatures and pressures. That's why you're guaranteed ±0.5 percent calibrated accuracy. That's why it operates — year after year — under the toughest conditions of shock, wear, corrosion, and weather.

Get the complete story on why the Type 12A Temperature Transmitter gives better performance with lower installation and maintenance. Write for Bulletin 13-17. The Foxboro Company, 466 Neponset Avenue, Foxboro, Massachusetts, U.S.A.



FOXBORO

REG U S. PAT OFF.

CIRCLE 67 ON READER-SERVICE CARD

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

People usually associate Optics with glass only. The following materials, successfully processed here by sawing, grinding and polishing or drilling are of value to designers, engineers and manufacturers. Most materials are supplied by our customers for their orders.

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ALUMINUM
ARSENIC TRISULPHIDE
BARIUM TITANATE
BRASS
CALCIUM TUNGSTATE
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
CORNING 707
CORNING 7052
FERRITE
FERROX
FLUORIDE, CALCIUM
FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNESIUM STANIDE
NICKEL OXIDE
NIOBIUM
PLATINUM
POTASSIUM BROMIDE
PYREX
QUARTZ, CRYSTAL
QUARTZ, FUSED
SAPPHIRE
SILICON
SODIUM CHLORIDE
STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
VYCOR
X-RAY LEAD GLASS
VANADIUM

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INSULATED WIRE
that will withstand
3000°F

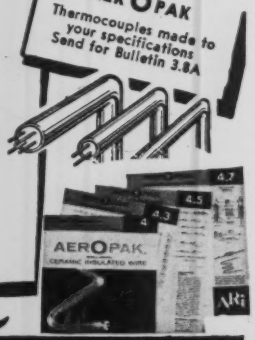
AERO PAK
Electrical Conductors
Thermocouple Wire
Miniature Heating Elements

- Available in outside diameters of .025 to .313
- One or more wires insulated from metallic sheath by a ceramic oxide.
- AerOPak can be bent and weldments performed without loss of insulation.
- Available in a variety of metal sheath materials, insulations and wires.

Ask for a new **revised** issue of Bulletin 4.

VSMF—Reel F and Reel A

AERO PAK
Thermocouples made to your specifications
Send for Bulletin 3.8A

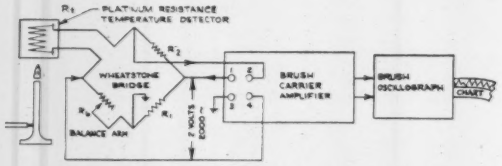


Aero Research
INSTRUMENT COMPANY, INC.
Dept. ICS, 315 No. Aberdeen Street, Chicago 7, Illinois
Sales Representatives throughout the United States and Canada

CIRCLE 69 ON READER-SERVICE CARD

Platinum Resistance Sensors

The Brush Universal Carrier Amplifier and a Platinum Resistance Temperature Sensor provide an excellent combination for recording temperature



from −320 degrees to +2000 degrees Fahrenheit . . . This method combines the advantages of the fast response characteristics of any Brush direct writing recorder with the high accuracy of a null-balanced platinum resistance temperature detector . . . The simple Wheatstone bridge . . . is the basic system for temperature measurement . . .

One advantage peculiar to resistance temperature sensors is that they are especially well suited to measuring the *average temperature* of a liquid or gas . . . The procedure is exactly the same as for single-point recording with the following exception: Select five similar platinum resistance thermometers with a nominal resistance of 20 ohms each, at 32 degrees F. (Ice Point). Connect these in series. The result will be a combined nominal resistance of 100 ohms at 32 degrees F . . . (*From new 12-page booklet "Temperature Recording from Platinum Resistance Sensors," Brush Instruments, div. of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.*

FOR THIS LITERATURE CIRCLE 194 ON READER-SERVICE CARD

CRATEX RUBBERIZED ABRASIVES

re·li'a·ble:
That which can always be counted upon to do what is expected or required

Micro-deburring, Smoothing, Cleaning, Polishing

Cratex reliability lowers costs

You can count on every Cratex item to perform just as you expect it to—exactly as the last one did and as the next one will. This is the key to efficiency in micro-deburring, smoothing, cleaning and polishing. YOU SAVE TIME because you know just what to expect in performance without experimenting or compensating. YOU SAVE REJECTS because with Cratex no unexpected irregularities occur to spoil work pieces.

WHEELS • POINTS • BLOCKS • STICKS • CONES in 4 grit textures for power or manual application. Sold through leading industrial supply distributors.

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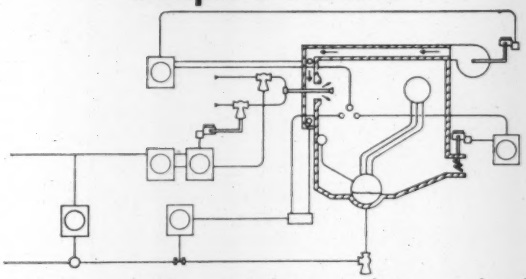
CIRCLE 70 ON READER-SERVICE CARD

Graphic Panels

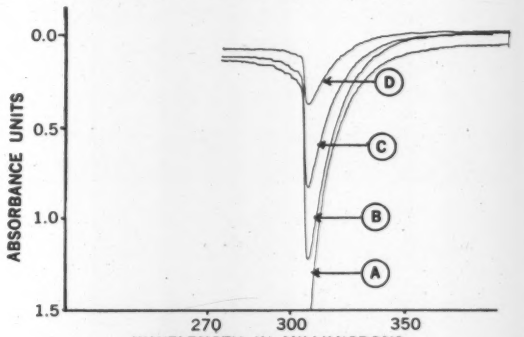


Modern graphic panel design is being employed more and more in advanced boiler room installations. This type of construction gives the operator a picture of the entire combustion process by spatially relating the various instruments and controls to their actual location and function within the system. The operator thus gets a "feel" of when and where events are taking place. An engineering layout for a typical Reliance Instrument graphic control panel is illustrated . . . (*From new 20-page Bulletin 1002, Reliance Instrument Div., Electro-Mech Corp., Norwood, N. J.*)

FOR THIS LITERATURE CIRCLE 195 ON READER-SERVICE CARD

Double-Beam Spectrophotometer

The Perkin-Elmer Model 202 Spectrophotometer covers two ranges: from 190 mμ to 390 mμ in the ultraviolet, and from 350 to 750 mμ in the visible . . . Known to the infrared spectroscopist who must



obtain precise absorption data under low energy conditions, optical null recording is unique to the low-cost ultraviolet/visible instrumental field . . . Optical null recording enhances accuracy and reliability, since its precisely-designed and manufactured logarithmic optical attenuator, with direct, short mechanical linkage to the recorder pen, assure stable and reproducible ordinate values.

Spectra show a quantitative analysis of the phthalic anhydride in a polyester resin bonding agent containing, in addition to phthalic anhydride, propylene glycol, styrene, and maleic acid . . . Curve A . . . is 1.0% sample in styrene vs. air. Curves B, C and D are, respectively 1.0%, 0.5% and 0.3% phthalic anhydride in styrene, vs. styrene in the reference beam . . . (*From new 8-page Bulletin MP 2615, Instrument Div., Perkin-Elmer Corp., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 196 ON READER-SERVICE CARD

NEW *Martin-Decker* **Precision Test Gauge** *makes pressure readings* **25% More Accurate**

8½" Dia. Dial — 25.13" Scale Length
12" Dia. Dial — 36.91" Scale Length

- **Big scale readings in small scale space!**
- **Greater Accuracy!**
- **Requires less panel space!**

360° Calibration makes Martin-Decker Scale 25% longer—gives 25% greater readability than models with 270° scale.

Ni-Span C Bourdon tube is temperature-stable, corrosion-resistant—superior to other alloys.

Tube tip bleed is standard equipment.

Movement calibrated to dial, with an accuracy of ± 0.15% or better.

Uniform linear increments. Protected front zero adjust.

Capacities from 60 PSI to 15,000 PSI.

Find out why more and more O.E.M. designers specify Martin-Decker Precision Test Gauges for measuring gas and fluid pressures.

MARTIN DECKER

Precision Pressure Instruments Testing—Weighing—Load and Force Measurement

Write for Technical Brochure T56

MARTIN DECKER PRECISION TEST GAUGES

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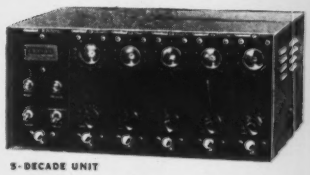
CIRCLE 71 ON READER-SERVICE CARD

accelerate production,

improve accuracy, cut costs with



5-DECADE UNIT

Tally-COUNT® electronic predetermining counter

Tally-COUNT automatically counts precise units into a container . . . determines exact footage from a roll . . . stops and recycles machine operations at preset counts, at electronic speeds.

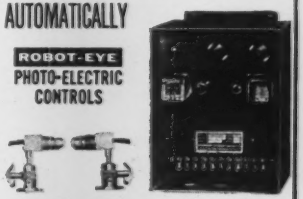
Tally-COUNT is actuated by external contacts or electronic impulses; control relay operates required mechanism: solenoid, motor, cut-off knife, etc.

Optional plug-in accessories: Batch Register, Photo-Electric Eyes, Footage Counters, Multiple Pre-Set Decades.

SPEEDS OPERATION
ELIMINATES GUESSWORK
BOOSTS PRODUCTION

Count, inspect, control production AUTOMATICALLY

ROBOT-EYE PHOTO-ELECTRIC CONTROLS



Plug-in relays, receptacles for plug-in connection of time delays, lamps and cells.

Write for Brochure JC-6

standard INSTRUMENT CORPORATION
657 BROADWAY, NEW YORK 12, N. Y.

CIRCLE 72 ON READER-SERVICE CARD

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

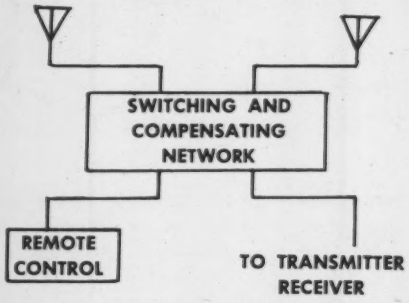
2 Sheffield AVE.

Newport, Rhode Island U. S. A.

CIRCLE 73 ON READER-SERVICE CARD

Data Link

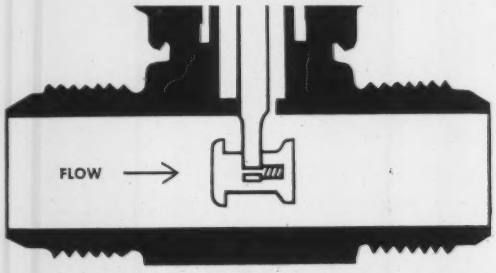
Airborne data link antenna (broad-band) systems provide anti-interference capabilities through selection of various radiation patterns at the discretion



of the operator . . . Provide optimum pattern shapes, low input VSWR . . . special radiation characteristics with standard and special airborne transmission equipment. By providing a choice of patterns, interference from a specific direction may be reduced and gain in a desired direction may be increased . . . One such system utilizes supersonic blade antennas, a phasing and switching network, a power divider and a remote control provision . . . It uses a pair of antennas, providing an omni-directional pattern or cardioid-shaped pattern with a null which can be positioned fore or aft at the operator's direction . . . (*From new folder with ten 2-page bulletins, Electrada Corp., Electronic Div.,* 11244 *Playa St., Culver City, Calif.*)

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

Flow Transducer



The Mark V Flow Transducer senses the rate of fluid flow as a product of the dynamic *forces* acting upon a fixed body immersed in the flow stream . . . Bonded strain gages in a four active arm bridge circuit, completely isolated from the fluid by a wall of stainless steel, faithfully translate this physical force into an electrical output which is proportional to the original rate of flow squared.

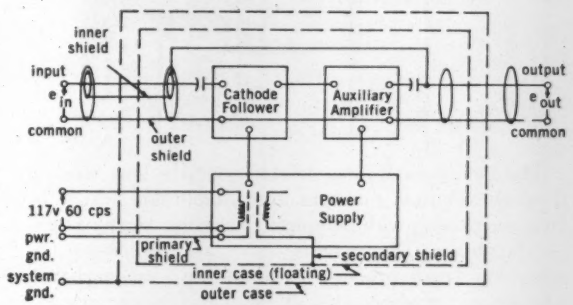
Electrical calibration of the Mark V is extremely simple and may be accomplished in a matter of seconds, with any type of indicating, recording, or control equipment . . . Accuracy: ½% or better. Range: from 0.1 gpm to some of the highest flow demands in industry, with a basic flow range ratio of approximately 10 to 1 in any single unit.

(*From new 4-page bulletin, Ramapo Instrument Co., Inc.,* 8 *First St., Bloomingdale, N. J.*)

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

Wideband Impedance Converter

Impedance Converter (super cathode follower) is used to buffer piezoelectric transducers and other high impedance signal sources from such instruments as: recorders; pre-amps; instrument amplifiers; ana-



log to digital converters; telemetering and voltage controlled oscillators—and other low impedance devices . . . High input impedance (1,000 megohm) permits low frequency response with capacitative signal sources. Maintains gain accuracy when coupled to resistive signal sources . . . The driven inner shield of the triaxial input cable reduces effective cable capacity seen by signal source to less than 2% of physical cable capacity . . . . (*From new 8-page Bulletin SCE-1, Computer Engineering Associates, Inc., 350 N. Halstead, Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 199 ON READER-SERVICE CARD

WORLD'S MOST ACCURATE AIR-PRESSURE REGULATOR

- **Holds pressure to 1/5 of 1/10 of 1% of its range over substantial variations in supply pressure, flow, and ambient temperature. Resolution: 1 part in 10,000 of range.**
- **No exhaust-valve "pick-up" or initial drop-off on dead-end service. No drift with time or periodic shutdown.**
- **Designed for rugged service and minimum maintenance.**
- **50,000 user-tested for 6 years. Accepted as *primary standard of reference.***

You can prove it! This new air pressure regulator is the world's most accurate and reliable device for precise control of air or gas pressure. Yet it costs no more than other pilot-operated regulators.

Key to its unequalled accuracy and instant response is its patented high-gain servo design, which uses regulated rather than supply pressure, and its stainless steel pressure capsule

Available in 2-25, 3-60, or 3-120 psi ranges for ⅛", ¼", or ⅜" NPT pipe at 15 U.S. stocking points. Standard trade and quantity discounts. *Write now for data sheet and prices.*

Some territories are still open for qualified technical sales representatives.

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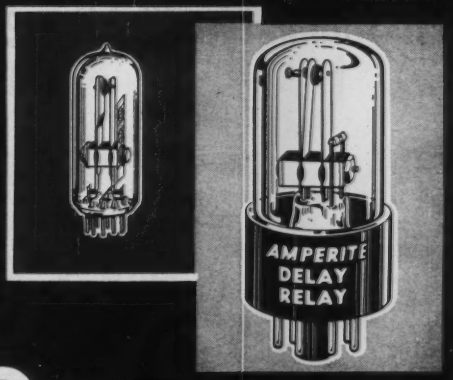
CIRCLE 74 ON READER-SERVICE CARD

AMPERITE

Thermostatic DELAY RELAYS



Only a glass seal offers true hermetic sealing . . assuring maximum stability and life!

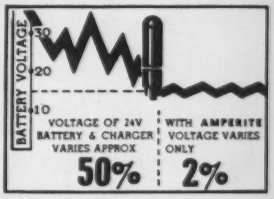
Delays: 2 to 180 seconds . . . Actuated by a heater, they operate on A.C., D.C., or Pulsating Current . . . Being **hermetically sealed,** they are not affected by altitude, moisture, or climate changes . . . **SPST only**—normally open or normally closed . . . Compensated for ambient temperature changes from —55° to +80° C. . . . Heaters consume approximately 2 W. and may be operated continuously . . . The units are **rugged, explosion-proof, long-lived,** and—**inexpensive!**

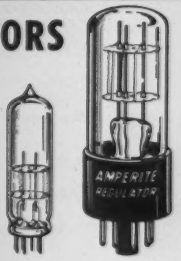
TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.** Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

PROBLEM? Send for Bulletin No. TR-81

AMPERITE

BALLAST REGULATORS





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—50° to +70° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

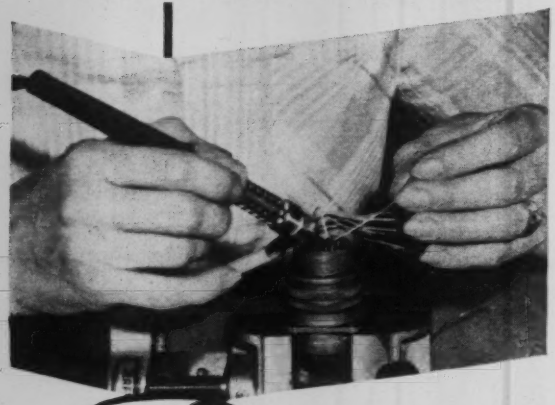
Write for 4-page Technical Bulletin No. AB-51

AMPERITE

561 Broadway, New York 12, N. Y. . . . CAnal 6-1446
In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

CIRCLE 75 ON READER-SERVICE CARD

For Fast, Precise Miniature and Sub-Miniature Soldering



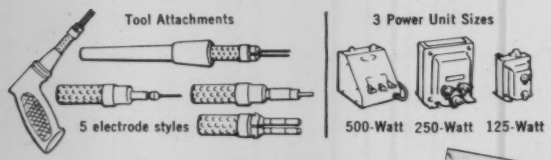
IDEAL THERMO-TIP®

RESISTANCE SOLDERING TOOLS

No Cold Flow • No Burn Damage • No Set-Up

Cut time, cost and damage on all precision miniature and sub-miniature soldering jobs. Ideal Thermo-Tip Soldering Tools use resistance heating principle to concentrate *all heat on the job*—instantly, without set-up or pre-heating. Versatile "Pencil Grip" handle is easily manipulated for close-quarter soldering of aircraft connectors, printed circuits, pin type plugs, terminals—practically any job requiring pin-point assembling accuracy. Thermo-Tip is activated only on contact with work—doesn't waste current, can't damage adjacent parts, can't burn operators. Solder immediately flows all around to form stronger, neater, more uniform joints. Unit is so lightweight a woman can use it all day without tiring. Has a perforated aluminum sleeve which dissipates heat for exceptionally cool operation. Available with "pencil grip" and "pistol grip" style tools.

IDEAL SOLDERING EQUIPMENT FITS EVERY NEED



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Sycamore, Illinois

Please send Catalog data on Ideal Soldering Equipment

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Company_____

Address_____

City_____ Zone_____ State_____

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CIRCLE 76 ON READER-SERVICE CARD

Rolling Diaphragms

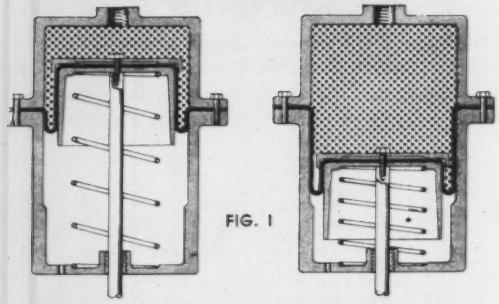


FIG. 1

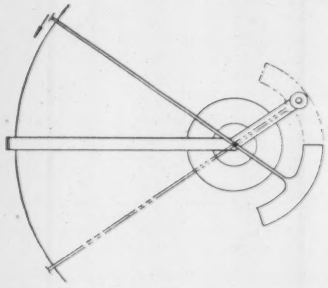
The Bellofram Rolling Diaphragm is a long stroke, deep convolution, constant area diaphragm which is free positioning with complete relaxation at any point in its stroke. Diaphragms . . . are responsive to extremely small pressure changes, have no mechanical spring gradient, no break-out friction effects, possess very low hysteresis qualities, are capable of extremely long strokes, and yet have a long flex life . . .

As the diaphragm and piston are moved in an axial direction, due to an applied pressure, the diaphragm will roll off the piston sidewall and onto the cylinder sidewall with a smooth and continuous frictionless motion . . . (*From new 28-page Bulletin BF-400-A, Bellofram Corp., Blanchard Rd., Burlington, Mass.*)

FOR THIS LITERATURE CIRCLE 200 ON READER-SERVICE CARD

Electronic Control Meter

The electronic control meter (Model 2547-2) is a contactless electromechanical module for indicating, controlling and monitoring wherever an electric signal is available . . . The mechanical arrangement shows

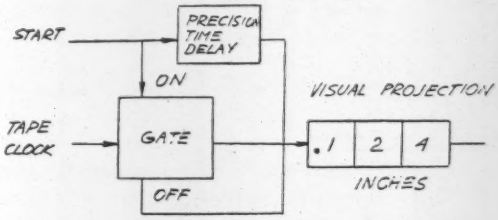


a shield attached to the rear extension of the D'Arsonval meter movement, which passes between the coils, creating an upset or disturbance in this inductive coupling . . . The isolated, transistorized electronic section contains an oscillating, sensing, amplifying and switching circuit designed to give maximum component life . . . If the input signal to the meter movement changes so that the coils are no longer shielded the control signal immediately goes "off". This in turn gives automatic resetting as the control signal goes "off" or "on" depending on the direction of the meter pointer travel in respect to the control setting . . . (*From new 4-page Data Sheet Form 344, International Instruments, Inc., Box 2954, New Haven 15, Conn.*)

FOR THIS LITERATURE CIRCLE 201 ON READER-SERVICE CARD

Digital Tape Recorder Analyzer

The DRA-1101 is a digital tape recorder analyzer which measures the performance characteristics of a digital magnetic tape system. It performs the following measurements: Start distance, stop distance, dynamic tape skew, dynamic speed variations. With a minimum of additional circuitry, the DRA-1101 can, as an independent module or as an additional operational feature of the analyzer, detect the drop-out characteristics of magnetic tape. Additionally, the unit can be utilized for life testing of record-reproduce heads of magnetic tape recorders . . . This is accomplished by pre-recording a reel of "one's" on each track of the tape and reproducing each track simultaneously through an equivalent number of comparators . . . (*From new 16-page folder, Telemetrics, Inc., 12927 So. Budlong Ave., Gardena, Calif.*)



FOR THIS LITERATURE CIRCLE 202 ON READER-SERVICE CARD

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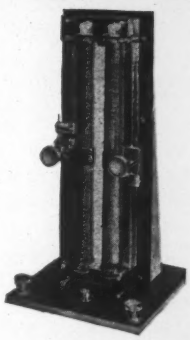
NIL TYPE M-12 PRECISION MANOMETER



The versatile micromanometer which can be operated at high working pressures. A simple U-tube with vernier readers makes it possible to offer this exclusive combination of features:

- 150 PSIG maximum working pressure.
- ± 0.001 inch sensitivity.
- Water or mercury can be used.
- Forward or reverse use without changing connections.
- Range —9 to +11 inches.

WRITE FOR BULLETIN 155

NATIONAL INSTRUMENT LABORATORIES, INC.

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CIRCLE 77 ON READER-SERVICE CARD

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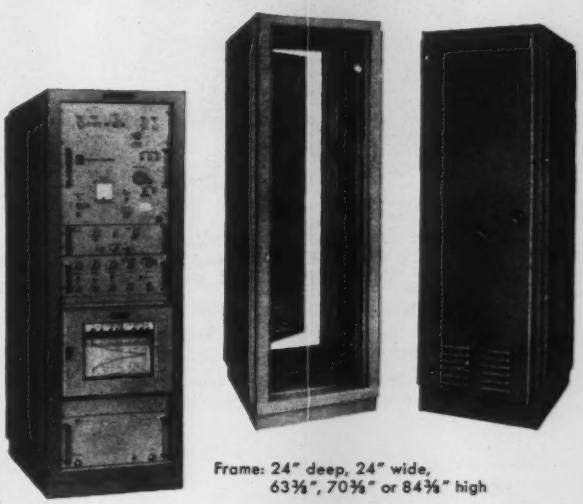

Frame: 24" deep, 24" wide, 63⅜", 70⅜" or 84⅜" high

Front panel space: 56", 63", 70" or 77" high

New Honeywell Modu-Mount* Cabinets

Now you can get standard enclosures to protect your valuable precision instruments and devices. New Honeywell Modu-Mount Cabinets are designed by experts to provide the ultimate in appearance, convenience and economy. Best of all, you can order them to fit your specific enclosure requirements.

The rugged steel frame can be left open or enclosed by panels and doors. You can specify such features as anti-tilt mobile base, wiring trough, lift-bars and eye-bolts, or floor levellers, vibration mounting and cooling louvers. And up to five Modu-Mount Cabinets can be supplied with a common base and wiring trough.

Modu-Mount Cabinets come in standard green, grey or brown baked enamel. Other colors are available at your request. For details, call your nearby Honeywell office. Or write Honeywell, Dept. IC-6-55, Minneapolis 8, Minnesota. *Sales and service offices in all principal cities of the world.*

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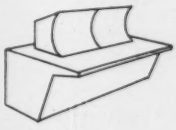

Honeywell will design and custom-build any cubicle, panel, console or other enclosure to your exact specifications. Special attention is given to these orders, and the finished product meets the most stringent requirements.

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AN INSTRUMENT TRANSMISSION FOR PRECISE MULTIPLE SELECTION OF SHAFT SPEEDS

Versatility of ten ratios . . . to 1000:1! Desired shaft speed can be quickly selected at the turn of a dial, without stopping the input shaft. Geared design provides exact repeatability and non-slip drive . . . ideal for new instrument design, breadboards, general laboratory applications.

OIL BATH LUBRICATION . . . SPEEDS UP TO 3000 R.P.M. . . . TORQUE TO 50 OZ.-IN. . . . VARIETY OF MOUNTING ARRANGEMENTS.

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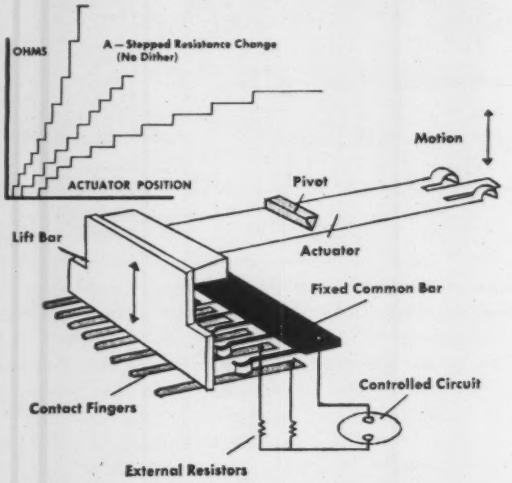
Brushless Rheostat

The Regohm Transducer converts linear or angular motion into electrical action for continuous, dependable, automatic control of any electrically controllable device . . . Works on the time-proved prin-



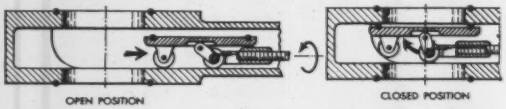
ciples of the famous Regohm Voltage Regulator and Servo Component . . .

The Regohm Transducer Actuator drives the Lift Bar about the Pivot producing vertical lift bar travel —sequentially moving the contact fingers to or away from the Common Bar to open or close the contacts, which in turn, shunt or insert the External Resistors in the Controlled Circuit. Thus, actuator motion results in controlled resistance changes. In the Regohm Transducer's simplest form, actuator motion results in stepped resistance changes . . . (*From new 4-page Bulletin* 5.501, *Rev.* 1, *Electric Regulator Corp., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 203 ON READER-SERVICE CARD

Hi-Vac Valves, Baffles

Because valves, baffles and traps are an integral part of the vacuum system, as much care must be taken in their selection as in any other compo-

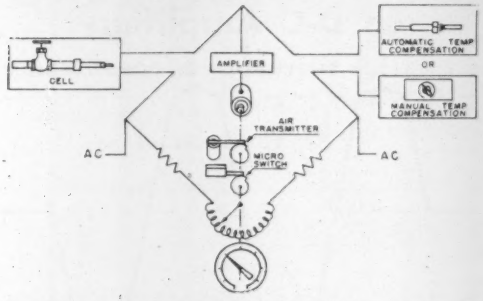


nent, if a system is to operate at optimum efficiency . . . VCS valves will seal vacuum-tight in either direction against atmospheric pressure and may be actuated against atmosphere or a vacuum . . .

A proven feature of VCS valves is the actuating mechanism employed for seating the valve-plate. This plate is guided by rollers and connected to a follower carriage by two hinged links, thus there is no scuffing of the gasket when opening and closing the valve-plate. To guarantee vacuum tightness, each valve is rigidly tested with a mass spectrometer-type leak detector . . . (*From new* 28-*page Bulletin* 10-1, *Consolidated Vacuum Corp., Sub. of Consolidated Electrodynamics/Bell & Howell, Rochester* 3, *N. Y.*)

FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

Electrolytic Conductivity



The RI is a compact self-balancing continuous indicator. An AC Wheatstone Bridge circuit is employed for electrolytic conductivity measurements . . . from the extremely high resistance of pure water and condensed steam, to the low resistance of concentrated solutions of acids, alkalis and salts . . .

One to four SPDT micro-switches, or one air transmitter or a combination of one air transmitter and up to two micro-switches can be furnished. Controls are back-set, cam-operated type.—(*From new 4-page Bulletin 6639D, Industrial Instruments Inc., 89 Commerce Rd., Cedar Grove, N. J.*)

FOR THIS LITERATURE CIRCLE 205 ON READER-SERVICE CARD

Standardized Thermowells

Standard wells are produced on a large quantity basis bringing about reduced cost and improved delivery . . .

Well failures, in most cases, are not due to the effect of pressure and temperature. The calculations necessary to provide adequate strength, under given conditions, are familiar enough to permit proper choice of wall thickness and material. Less familiar, and more dangerous, are the vibrational effects to which wells are subjected. Fluid, flowing by the well, forms a turbulent wake (called the Von Karman Trail) which has a definite frequency based on the diameter of the well and the velocity of the fluid. It is important that the well have sufficient stiffness so that the wake frequency will never equal the natural frequency of the well itself. If the natural frequency of the well were to coincide with the wake frequency, the well would vibrate to destruction and break off in the piping . . . A recommended maximum velocity rating can be found for every standard well length and material cataloged . . . (*From new 12-page Catalog 7L, Alloy Engineering Co., 224 De Kalb Ave., Bridgeport 7, Conn.*)

VELOCITY RATING *
FEET PER SECOND

MATERIAL	INSERTION LENGTH — "U"					
	2	4	6	8	10	12
Brass	362 (74)	115 (37)	51.4 (24.7)	28.9 (18.5)	18.5 (14.8)	12.8 (12.3)
Carbon Steel	422 (156)	155 (78)	69.1 (52.1)	38.9	24.9	17.3
A.I.S.I. 304 & 316	450 (223)	162 (112)	72.2	40.6	26.0	18.1
Monel	382 (147)	145 (73.8)	64.7 (49.2)	36.4	23.3	16.1

FOR THIS LITERATURE CIRCLE 206 ON READER-SERVICE CARD

INCREASE RECORDER VERSATILITY

MULTI-SPEED **CHART DRIVE** FOR STRIP CHART RECORDERS

BUILT BY — HONEYWELL — LEEDS & NORTHRUP — BRISTOL — WHEELCO — GENERAL ELECTRIC (EASILY FIELD MOUNTED)

Matches Chart Speed to Test Requirements • Quick dial selection of eight speeds • Improves resolution and readability of plotted curves • Provides greater total chart speed range • Saves chart paper • Saves valuable time.

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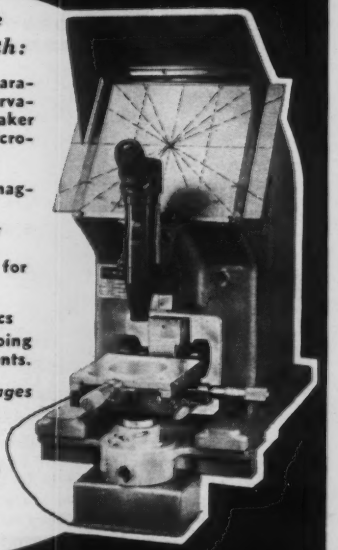
NEW *Wilder* DUPLEX PROJECTOR



As a double feature it is both:

A small parts Comparator with screen observation and a Toolmaker Microscope for microscopic observation

***With* 4 interchangeable magnifications**
- **transmitted light for shadow images**
- **surface illumination for reflected images.**

***Plus* High-Precision Optics**
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Coordinate Measuring Stages available optionally

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The easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A Stik For Every Temperature from 113° F. to 2000° F.

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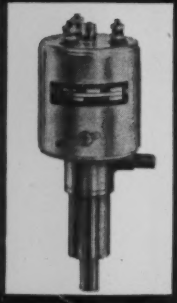
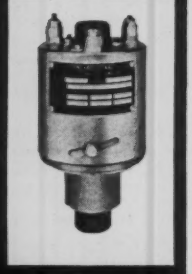
Adjustable within a speed range while running





1 Switch UNDERSPEED OR OVERSPEED

2 Switches UNDERSPEED AND OVERSPEED

3 Switches UNDERSPEED, INTERMEDIATE AND OVERSPEED

All "STANDARD" Speed Sensitive Switches can be furnished to TRIP at any speed between 300 and 6000 RPM. On special order higher or lower speed operation can be supplied. Also special body styles, mounting pads, drives, terminal connectors and caps are available.

Write for Bulletin 504 for further information

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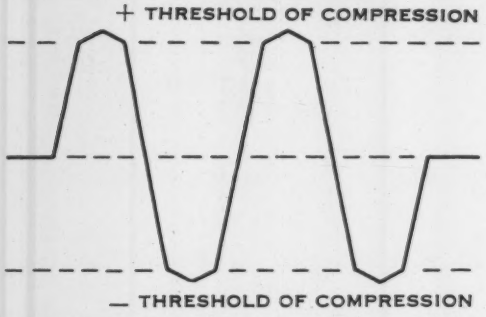
CIRCLE 83 ON READER-SERVICE CARD

Special Features Available on D-C Amplifiers



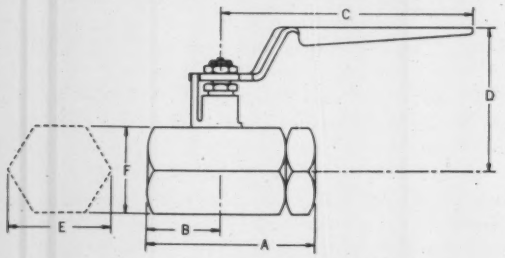
OUTPUT OF AMPLIFIER WITH DYNAMIC COMPRESSION, SHOWING 10:1 REDUCTION OF VOLTAGE GAIN IN REGIONS OF COMPRESSION.

The dynamic compression circuit produces an abrupt 10:1 reduction in voltage gain whenever the output signal exceeds a certain predetermined magnitude. Unexpected overscale signals will therefore not cause overloading and subsequent loss of data.

A substantial degree of galvanometer protection is also afforded. Threshholds of compression may be specified within the range ±10 volts to ±28 volts referred to the output. Compression is accomplished with negligible delay or hysteresis effects . . . The Model 3557 Differential D-C Amplifier is a wide-band, fully-isolated amplifier with overload protection. Input signals of up to ±10 volts will not cause overloading at any gain setting. Common-mode-rejection, with 1000 ohms of line unbalance, is in excess of three million to one at 60 cps. Balance controls are not required. The amplifier is ideally suited for commutating a large number of input signals originating from a variety of ground points . . . (*From catalog kit of DC and AC Amplifiers, DC Micro Voltmeters, and Test Instruments; Dynamics Instrumentation Co.*, 1118 *Mission St., South Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 207 ON READER-SERVICE CARD

Bar Stock Ball Valve

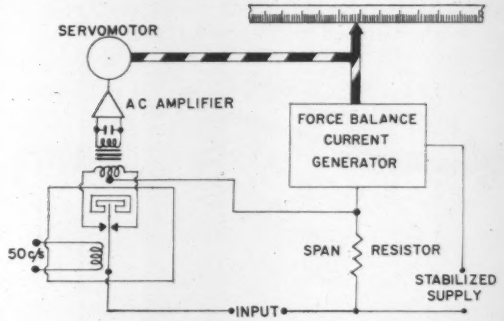


Flo-Ball Series 712, screwed ends—bar stock, (with) Teflon seats and seals doesn't freeze or jam . . . the seat doesn't score . . . gives zero leakage . . . has greater flow capacity than any plug ... and the lowest torque in the industry . . . (*From new 6-page Bulletin* 712-361, *Hydromatics, Inc.*, 5 *Lawrence St., Bloomfield, N. J.*)

FOR THIS LITERATURE CIRCLE 208 ON READER-SERVICE CARD

Slidewireless Potentiometer

The Kelvin Hughes Recorder is of the null-balance type in which the input voltage is continuously compared against a voltage generated across a fixed



resistor. As the input voltage varies, balance is obtained by a Force Balance Unit which varies the current through the resistor until a voltage equal and opposite to the input voltage is developed across it. This unique servo-operated closed loop employs a robust feedback coil and a photo-conductive system. The movement of the servo mechanism directly proportional to the current (and therefore to the input voltage) drives an indicator pointer across the scale, and the print head across the chart.

Special features are: (1) Negligible current is drawn from the input source, (2) use of slidewires is avoided . . . (*From 6-page IND789, Kelvin Hughes America Corp., Box* 1951, *Annapolis, Md.*)

FOR THIS LITERATURE CIRCLE 209 ON READER-SERVICE CARD

YOU CAN OWN THIS VALUABLE AUTHORITY ON PERMANENT MAGNETS FOR *ONLY* $10. You'll find the answers to almost all of your questions about permanent magnets in this authoritative Crucible handbook — because its 346 pages cover everything from selecting magnet alloys for TV systems to interpreting molecular fields.

Just look at the chapter headings: Permanent Magnet Design • Permanent Magnet Measurements • Theory of Ferromagnetism • Electromagnetism • Permanent Magnet Steels • Cast Alnico • Permanent Magnet Alloys • Standard and Stock Magnets • Ferrimag • Magnetization and Demagnetization.

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CIRCLE 84 ON READER-SERVICE CARD

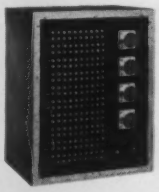
PACE

THERMOCOUPLE REFERENCE JUNCTIONS

INSURE TEMPERATURE STABILITY WITHIN ±1/10°F

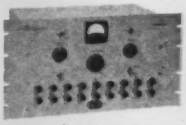
Bridge stabilized for laboratory accuracy, PACE BRJ Series Reference Junctions are available with up to 100 channels. They are designed and built to operate reliably from the 115 volt 60 cycle line. Temperature stability and uniformity for long term unattended operation are within ±1/10°F. The instruments provide precision beyond the capabilities of ice baths and cold junction compensators and junction accuracy matching NBS calibrated premium thermocouple wire curves within ±1/5°F. Special models include below ambient and field adjustable reference temperatures.

Series BRJ Reference Junctions



PACE Model TC2R Thermocouple Control Units, when combined with a BRJ Reference Junction and any galvanometer type oscillograph, provide a complete system for the simultaneous recording of independent channels of temperature information. Two calibrating ranges of ±10 and ±100 millivolts are featured. A variable bucking voltage, range ±5 millivolts, is included.

Model TC2R Control Unit



Write today for detailed information on PACE BRJ Reference Junctions, TC2R Control Units, Pressure Transducers, Instrumentation Systems and in-flight Thermocouple Reference Junctions.

PACE *engineering company*

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CIRCLE 85 ON READER-SERVICE CARD

3 new instruments for process control

MV-1 POTENTIOMETER

For testing, calibrating or servicing newest process controllers and amplifiers which convert millivolt input signals into proportional currents for control or telemetering. Combines all functions of precision potentiometer, millivolt source and milliammeter. 1/10 of 1% accuracy. 5⅛" x 8" x 5⁹⁄₁₆". 5½ lbs.

THE AUTOCOMP 1

For instrument checking and thermocouple measuring. Gives automatic cold junction compensation to devices used for measuring or controlling with thermocouples. Exclusive circuit employs thermistor network to match non-linear characteristics of thermocouples with output characteristics of bridge. 5⅛" x 8" x 5⁹⁄₁₆". 6 lbs.

RU-1 "RUN UP" SOURCE

Combination millivolt and milliampere "run up" source for instrument calibration. Checks newest process controllers and amplifiers. Current source furnished by two self-contained 90V batteries made to give stable, uniform outputs with cold cathode type voltage regulator tube. Self-contained. 5⅛" x 8" x 5⁹⁄₁₆". 10 lbs.

TECHNIQUE ASSOCIATES

TECHNIQUE

A Division of Duncan Electric Co., Inc.
P. O. BOX 91 • INDIANAPOLIS 6, INDIANA
CIRCLE 86 ON READER-SERVICE CARD

GREEN PRINTED CIRCUIT DRILL

A Pneumatic Attachment on The Green Model D2 Pantograph Engraver rapidly drills holes in printed circuits by tracing templates.

- Drill as many as 100 holes per minute. Foot switch actuates air powered operation.
- Drill speeds and feeds have independent adjustments. Feed regulated by air pressure.
- Spindle speeds up to 26,000 rpm. Permits use of carbide drills when required.
- D2-201 air attachment includes spindle air cylinder, regulating valve and pressure gauge, foot switch, filter and oiler, ready to operate when connected to compressor.

The Model D2 Heavy Duty Pantograph Engraver features ratios of 2 to 1 to infinity. Unobstructed on three sides to handle large work. Micrometer adjustment for depth of cut. Vertical range 10" adjusting copy table automatically with pantograph.

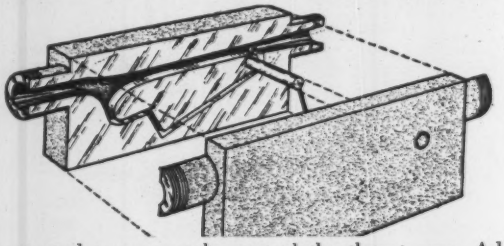
GREEN INSTRUMENT CO., INC.
Dept. 83, 295 Vassar St. • Cambridge 39, Mass.

FOR FULL DETAILS, WRITE, WIRE OR CALL

CIRCLE 87 ON READER-SERVICE CARD

Aerodynamic Nozzle Reduces Turbulence

A distinguishing feature of Flextrol automatic control and regulator units is the unique Vari-Valve (see Figure). This valve employs a rectangular, open end sage nozzle designed aerodynamically to form a good subsonic entry to the throat. One plate of the nozzle



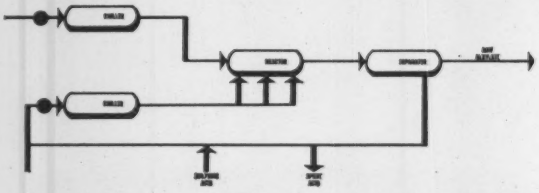
is actuated to accurately control the throat area. Advantages of this valve principle are the linear-area-versus-position relationship, ease of maintenance, low power actuator requirements, and the fact that the flow characteristics are accurately described by the basic orifice equation for gasses. Any size or pressure range up to 10,000 psi is available.

The Vari-valve, controller amplifier, and flow computer make up a simple metering system for metering gas flow over ranges requiring several orifices or venturi meters. The system functions to hold a fixed pressure ratio across the valve and continually indicates flow rates and accumulation. Applications include large flows, where conventional valves fail due to vibration and noise caused by the large flow.—*Physics for Industry, Inc., P. O. Box* 8108, *Rochester* 17, *N. Y.*

FOR THIS LITERATURE CIRCLE 210 ON READER-SERVICE CARD

Alkylation Reactor

In the more common alkylation processes, isobutane and butylenes are reacted to form the isomers of isooctane. Since many side reactions such as butylene



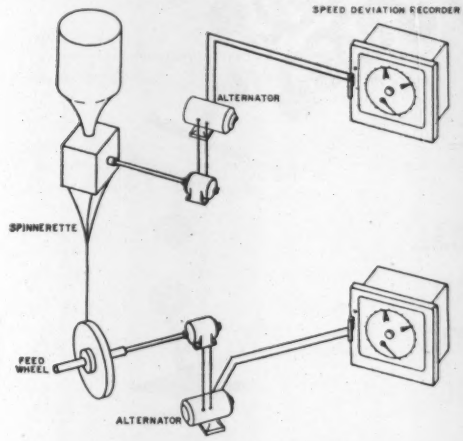
polymerization are possible, it is important that all variables be closely controlled to achieve optimum profitability from the process. Aside from reactor temperature and residence time, the most important control variables are the ratio of isobutane to the butylenes, and the ratio of acid to the butylenes. Since the compositions of the feed streams are continuously changing, it is important that their concentrations be continuously monitored in order to keep the isobutane to olefin and acid to olefin ratios constant . . . (*From series of* 14 *Application Data Sheets, providing information on use of Process Vapor Fractometer in Chemical and petroleum processes, Instrument Div., Perkin-Elmer Corp., Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 211 ON READER-SERVICE CARD

(*Cont. on page* 1102)

Frequency Deviation

The General Electric HF Strip Chart and HR Round Chart Frequency Deviation Recorders indicate and record deviations from a predetermined (adjustable)

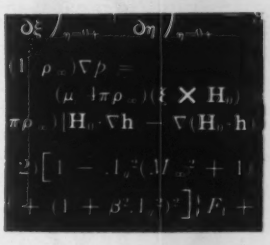


frequency . . . Man-made fiber spinning machines utilize many small synchronous motors to drive metering pumps, feed rolls, and winders . . . The Type HF and HR frequency deviation recorders are used to insure that the controls are maintaining the motor speeds at proper level . . . (*From* 4-*page Bulletin GEZ*-3316, *Instrument Dept., General Electric, West Lynn, Mass.*)

FOR MORE INFORMATION CIRCLE 212 ON READER-SERVICE CARD

New Solutions in Simulation

The analog computer's speed, lower cost, ease of programming, and improved output data presentation have been crossed with the digital computer's unique capacity for data storage and time-sharing of components . . . Highly complex problems involving statistical iteration, repetitive procedures, boundary val-



ues, and partial differential equations, which until now defied computer solution, are readily solvable with Computer Systems, Inc.'s recent revolutionary development—DYSTAC . . .

From the Computer Center have emerged important ideas for "impossible" solutions to such problems as: dynamic distillation, transient countercurrent heat exchange, thermal wave propogation in heat conduction, non-linear programming, defining non-linear forcing functions in systems engineering, (etc.) . . . (*From new* 20-*page bulletin Computer Systems, Inc., a Schlumberger Sub.,/formerly Mid-Century Instrumatic Corp.,/Culver Rd., Monmouth Junction, N. J.*)

A QUICK DISCONNECT THERMOCOUPLE CONNECTOR

with

A FLEXIBLE HOSE ASSEMBLY

COMPLETELY WATERPROOF

- All stainless fittings throughout complete assembly
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- Each unit is factory assembled and carefully inspected prior to shipment
- Standard 16 gauge extension leadwire is supplied inside each hose assembly
- Flexible hose is galvanized or brass interlock construction with polyvinyl covering. Vapor proof and resistant to oils, chemicals and inclement weather conditions
- Thermocouple Products Company series 100, 101, 102, 103 and 104 connectors are interchangeable to provide you with the desired calibration
- Can be readily connected to your existing conduit outlets with standard male connectors provided with each unit (Optional thread sizes available)
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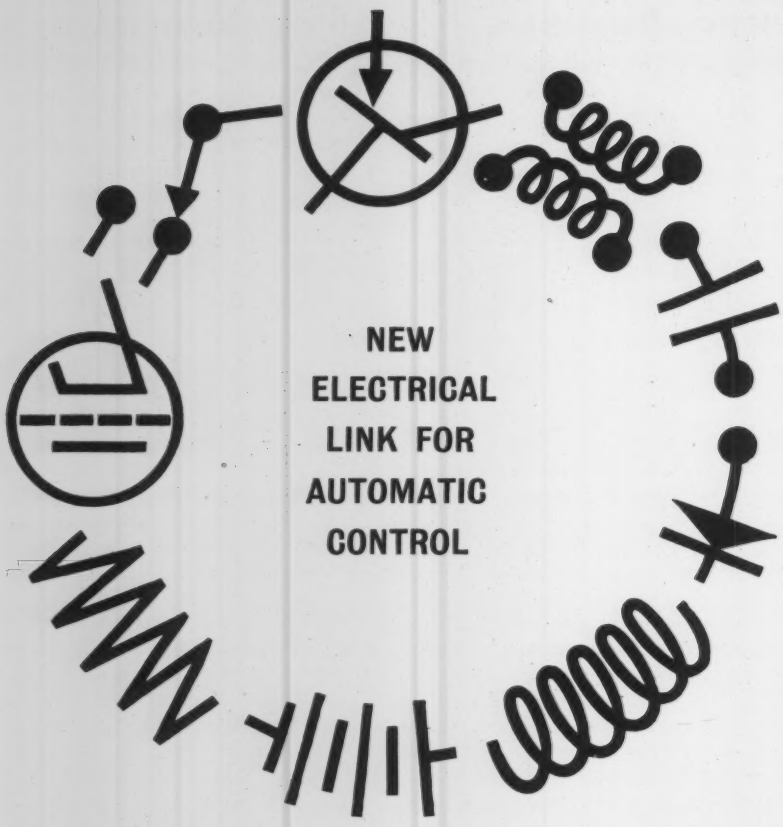
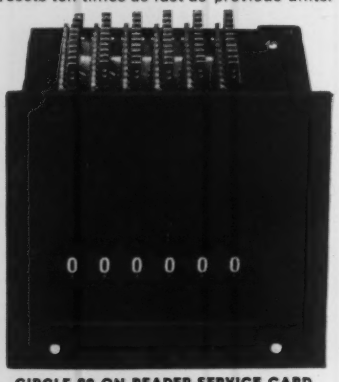
CIRCLE 88 ON READER-SERVICE CARD



New Veeder-Root high speed digital readout counter meets new needs in automation and system design. It's precision engineered to record, display and electrically transmit accumulated digital levels. More than that, it's a fresh approach to a widening range of automation needs . . . an ingenious electrical link for digital indication, data recording, storage and transmission, automatic sequencing, predetermining control. See what this versatile unit can do for your equipment or designs. Write Electrical Section, Veeder-Root Inc., Hartford 2, Connecticut. **count on . . . VEEDER-ROOT**

Series 1744 High-Speed Digital Readout Counter saves time and labor by eliminating manual counting and recording of production. It counts twice as fast, resets ten times as fast as previous units.



CIRCLE 89 ON READER-SERVICE CARD

The Instrument Industry

An Economic Report by Richard Rimbach

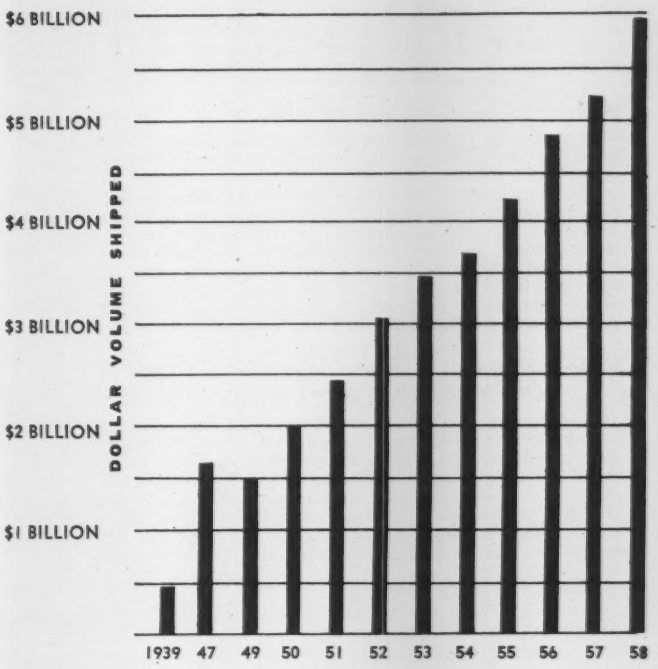


Fig. 1. The instrument industry dollar volume, as defined by the Census of Manufactures.

IN THE JANUARY 1954 issue of this publication, the writer presented a report on "The Instrument Industry—today and tomorrow." This report was the first in the nation to reveal that the Instrument Industry was a multi-billion dollar industry.

The most recent Census of Manufactures was made for the year 1958, issued by the Department of Commerce. The following have been taken from these industry reports.

Table 1—Code Classifications

The Instrument Industry includes the following S. I. C. Code Classifications of the Census of Manufactures:

1941—Sight and Fire Control Equipment

This industry comprises establishments primarily engaged in manufacturing sighting and fire control equipment, but which are not engaged in manufacturing optical lenses and prisms. Important products of this industry include bomb sights, gun data computers, percentage correctors, wind correctors, directors and sound locators.

3229—Pressed and Blown Glassware

This industry includes establishments engaged primarily in the manufacture of pressed and blown glass and glassware, not elsewhere classified.

3545—Machine Tool Accessories and Measuring Devices

This industry comprises establishments primarily engaged in manufacturing cutting tools, precision measuring tools, and attachments and accessories for machine tools and for other metalworking machinery, not elsewhere classified.

3571—Computing and Related Machines

This industry comprises establishments primarily engaged in the manufacture of adding, calculating, tabulating and bookkeeping machines; electronic computing machines; card-punching, sorting and tabulating machines and cash registers.

3576—Scales and Balances

This industry comprises establishments engaged primarily in the manufacture of weighing devices of all types, including those with automatic computing mechanisms and coin-operated scales.

3591—Valves and Fittings, except Plumbing

This industry comprises establishments engaged primarily in the manufacture of valves for controlling the flow of liquids or gases in pipes and mains; for machinery, including parts and fittings for each valve.

3613—Electrical Measuring Instruments

This industry comprises establishments engaged primarily in the manufacture of pocket, portable, panelboard, and graphic recording instruments for measuring electricity, such as voltmeters, ammeters, watt meters, watt hour meters, demand meters and other meters and indicating instruments. It also includes es-

tablishments engaged in manufacturing meter transformers and analyzers for testing the electrical characteristics of internal combustion engines, radio apparatus, etc.

3616—Electrical Control Apparatus

This industry comprises establishments primarily engaged in the manufacture of switchgear, switchboard apparatus and industrial electrical controls. Important products of this industry include power switches, circuit breakers, contactors and similar switchgear for general industrial application; switchboards and cubicles, control and metering panels, power fuse mountings, and similar switchboard apparatus and supplies; and industrial controls such as motor starters and controllers, electromagnetic brakes, and electronic inspection and gaging apparatus and positioning controls.

3662—Radio and Television Transmitting, Signaling, and Detection Equipment and Apparatus

This industry comprises establishments primarily engaged in manufacturing (1) radio and television broadcasting equipment; (2) electric communication equipment and parts, except telephone and telegraph; (3) electronic field detection apparatus, light and heat emission operation apparatus, object detection apparatus and navigation electronic equipment, and aircraft and missile control systems; and (4) other electric and electronic communication and signaling products, not elsewhere classified.

3673—Transmitting, Industrial, and Special Purpose Electron Tubes

This industry comprises establishments primarily engaged in manufacturing transmitting, industrial, and special purpose electron tubes.

3811—Engineering, Laboratory, and Scientific and Research Instruments and Associated Equipment

This industry comprises establishments primarily engaged in manufacturing laboratory, scientific, and engineering instruments such as nautical, navigational, aeronautical, surveying, drafting, and instruments for laboratory work and scientific research (except optical instruments).

3821—Mechanical Measuring and Controlling Instruments, except Automatic Temperature Controls

This industry comprises establishments primarily engaged in manufacturing industrial process instruments, for indicating, recording, measuring and controlling temperature (except automatic temperature controls—Industry 3822), pressure and vacuum, fluid flow and liquid level, mechanical motion, rotation, humidity, density, acidity, alkalinity and combustion; dial pressure gages; physical property testing apparatus such as hardness, tension, compression, torsion, ductility, elasticity testing apparatus.

3822—Automatic Temperature Controls

This industry comprises establishments primarily engaged in manufacturing automatic temperature controls activated by pressure, temperature, level, flow, time, or humidity (including pneumatic controls) of the type principally used as components of household apparatus.

3831—Optical Instruments and Lenses

This industry comprises establishments primarily engaged in the production of optical lenses and prisms, and in manufacturing optical instruments such as microscopes, telescopes, field and opera glasses; and optical measuring and testing instruments such as refractometers, spectrometers, spectroscopes, colorimeters, polariscopes, etc.

3871—Watches and Clocks

This industry comprises establishments primarily engaged in manufacturing clocks (including electric), watches, mechanisms for clock-work-operated devices, and clocks and watch parts, except watch crystals.

Table 2—Annual Dollar Volume of Industries Covered in Table 1, Reported by Seven-Digit Code(000 Dollars omitted)

19410	Sighting and fire control equipment, made from purchased lenses	585,983
3229081	Scientific and laboratory glassware	24,405
3229082	All other technical glassware (except electronic tube blanks)	2,804
3229083	Industrial glassware, including gauge glass, instrument faces, machine parts, glass knobs, meter covers, pumps, battery jars, etc.	13,574
3229084	Optical instrument lens blanks	1,450
3545200	Precision measuring tools, not specified by kind	8,156
3545211	Machinist's comparators	7,191
3545213	Fixed size limit gages, fixture type	3,895
3545215	Fixed size limit gages, thread type	6,078
3545217	Adjustable size limit gages	1,810
3545221	Gage blocks	1 967
3545261	Dial indicators	4,658
3545298	Other machinist's precision tools (including micrometers, calipers, and dividers)	27,116
3571012 (part)	Electronic computing and associated information processing equipment, digital	261,201
3571012 (part)	Electronic computing and associated information processing equipment, analog	9,067
3571012 (part)	Electronic computing equipment, not specified by kind (primarily for aircraft missiles and related uses)	54,031
3571022	Revolution counters	15,256
3576000	Scales and balances, not specified by kind	2,152
3576011	Railroad track and motor truck scales	6,477
3576021	Bench and portable industrial scales	6,988
3576023	Built-in scales (includes floor and dormant)	2,961
3576026	Predetermined-weight scales and automatic weighing and filling	11,695
3576029	Miscellaneous industrial scales (includes special purpose crane, suspension, tank, and hopper scales)	7,244
3576071	Laboratory precision balances (includes accessories, attachments and parts)	3,761
3576083	Accessories, attachments, and parts for scales and balances (sold separately)	4,881
3591123	Pop safety valves and relief valves (over 15 lbs. W.S.P.), steel (carbon and alloy)	25,826
3591125	Pop safety valves and relief valves (over 15 lbs. W.S.P.), brass and bronze	14,057
3591131	Automatic diaphragm actuated regulating valves	69,794
3591133	Automatic float actuated regulating valves (including float cages)	5,414
3591135	Other automatic regulating valves	57,456
3591137	Compressed gas cylinder valves	8,864
3591121	Pop safety valves and relief valves (over 15 lbs. W.S.P.), iron	7,024
3612100	Specialty transformers not specified by kind	3,024
3612198	General purpose and miscellaneous Applications involving voltages of 600 volts or below	27,268
3613000	Electrical measuring instruments, not specified by kind	16,793
3613100	Integrating instruments, electrical, not specified by kind	1,848
3613111	Electrical integrating instruments, A.C. watt-hour meters, single phase	41,051

3613115	Electrical integrating instruments, A.C. watt-hour meters, polyphase	8,094
3613133	Electrical integrating instruments, combined watt-hour and demand meters, single phase and polyphase and combined watt-hour and time switch meters	9,278
3613141	Demand meters (including KW and KVA)	1,821
3613151	Other electrical integrating meters including D.C. watt-hour meters, ampere-hour meters, and other miscellaneous integrating instruments not included in classifications 3613111, 3613115, 3613133, 3613141	12,124
3613161	Parts for integrating meters, electrical type (including meter mounting and test equipment) sold separately	14,593
3613200	Test equipment for testing electrical, radio and communication circuits and motors, not specified by kind	21,643
3613212	Oscilloscopes designed primarily for electronic use	34,901
3613215	Other types of oscilloscopes and oscillographs	7,488
3613222	Voltage, current and power measuring instruments (including electronic) such as volt-ohm-milliameters, vacuum tube voltmeters, etc.	22,389
3613239	Analyzers for testing characteristics of internal combustion engines and auxiliary equipment	14,042
3613245	Tube characteristics measuring instruments	11,613
3613251	Micro-wave test equipment	30,255
3613257	Signal generators	31,605
3613268	Frequency measuring equipment	18,391
3613281	Parts for electrical test equipment, sold separately	9,539
3613298	Other test equipment, including broadcast transmitter test equipment, resistor, capacitor, and inductor measuring equipment, etc. (including kits)	138,792
3613300	Other electrical measuring instruments, not specified by kind	6,128
3613311	Panel type instruments, nominal size 4½" and smaller. Initial accuracy with +2% of full scale deflection for all types except rectifier types which shall be within ±5% (excluding instruments for use on motor vehicles and aircraft)	22,869
3613319	Other panel type instruments, excluding those for use on motor vehicles, but including aircraft types	17,388
3613321	Switchboard type instruments 4½" nominal size and larger with accuracy within ±1% of full scale	8,686
3613331	Industrial portable ammeters, voltmeters, watt-varmeters, etc. (including hook-on and split core current measuring types)	3,377
3613335	Laboratory portable instruments—with accuracies within ±1% up to 1/10% of full scale and better, all case sizes	4,904
3613345	Other indicating instruments, except motor vehicle, and test equipment	13,838
3613361	Recording instruments (portable and for panel mounting) not including control types	37,380
3613371	Parts for indicating and recording instruments	10,837
3613375, 3613382, and 3613384	Instruments and meter transformers (current and potential) and tripping transformers	21,176
3613385	Ammeters and voltmeters for motor vehicles	3,469
3616127	Time switches (repetitive with respect to fixed time of day)	7,065
3616129	Other switches (excluding snap, toggle, push, etc. but include meter service equipment, other than meter mounting and test devices)	19,631
3662241	Industrial (closed circuit) television including cameras	7,710
3662400	Electronic navigational aids, not specified by kind	710
3662411	Electronic navigational aids (includes GCA, ILS, Loran, Tacan, etc.)	202,452
3662500	Electronic search and detection apparatus, including radar, infrared and sonar, not specified by kind	935
3662511	Electronic, search and detection apparatus, including radar, infrared, etc. (excluding sonar)	872,303
3662551	Sonar	44,618
3662600	Ultrasonic equipment	43,040
3662631	Telemetering equipment	50,367
3662651	Other electronic military, industrial and commercial equipment, including electronic meteorological equipment and systems (ray-wind, radio-sonde, etc.); facsimile equipment (except telegraph); etc.	185,094
3662661	Magnetic amplifiers	6,085
3673061	Cathode ray tubes (including oscilloscopes, camera pick-up tubes, monoscopes, storage tubes, iconoscopes, and orthicons) excludes TV picture tubes	22,724
3673098	Electro tubes, miscellaneous type transmitting, industrial and special purpose tubes (includes ballast, photo, photo multiplier, vacuum capacitor, vacuum switch, vacuum relay, vacuum gauge, battery charger rectifying tubes, traveling wave, backward wave oscillators, etc.	39,264
3811000	Scientific Instruments not specified by kind	19,726
3811100	Aircraft flight, nautical, and navigational instruments and automatic pilots, not specified by kind	6,732
3811111	Flight instruments, and automatic pilots (excluding gyroscopes)	211,183
3811121	Gyroscopes, vertical	14,950
3811123	Gyroscopes, directional	5,076
3811125	Gyroscopes, free, torqued and untorqued	1,602
3811127	Gyroscopes, rate	15,296
3811141 & 3811143	Gyroscopes, integrating rate (nonfloated) and fully floated	7,032
3811198	Other nautical and navigational instruments, except electronic	386,627
3811200, 3811211, 3811241, and 3811260	Surveying and drafting instruments and apparatus, except optical (including surveying instruments, transits, drawing instruments, drafting machines, slide rules, planimeters, integrators, photogrammetric equipment, etc.)	16,459
3811261	Other instruments (excluding aircraft, nautical, and navigational instruments and apparatus, electrical quantity measuring instruments and industrial instruments)	186,190
3811271	Laboratory precision balances (including accessories, attachments and parts)	5,692
3811281	Laboratory furniture; cabinets and cases, wood	26,471
3811285	Laboratory furniture; cabinets and cases, metal	21,583
3811289	Laboratory furniture, other (tables, stools, reagent shelves, etc.)	9,460
3811311	Other laboratory and scientific instruments excluding aircraft, nautical and navigational instruments and apparatus, electrical quantity measuring instruments and industrial process instruments	185,461
3821000	Mechanical measuring and controlling instruments, except automatic temperature controls, not specified by kind	19,147
3821111	Aircraft engine instruments, except flight	55,481
3821211	Gas integrating meters, nonelectrical type	40,806
3821231	Water integrating meters, nonelectrical type	47,886
3821298	Other liquid meters, integrating, nonelectrical type, including gasoline dispensing	30,412
3821200	Integrating meters, other than electrical, not specified by kind	254
3821300	Industrial process instruments, not specified by kind	21,289

3821311	Thermometers (glass stem and bimetal), industrial and laboratory	10,194
3821313	Thermometers (glass stem and bimetal), clinical	6,698
3821315	Thermometers (glass stem and bimetal), household	11,259
3821319	Pyrometers	27,994
3821322	Other temperature measuring instruments (including filled system thermometers)	27,363
3821333	Pressure and vacuum nontransmission	33,875
3821335	Pressure and vacuum, pneumatic transmission	12,754
3821337	Pressure and vacuum, electric transmission	6,539
3821343	Fluid flow and liquid level, nontransmission	26,349
3821345	Fluid flow and liquid level, pneumatic transmission	14,487
3821347	Fluid flow and liquid level, electric transmission	13,159
3821348	Gas and chemical analysis	17,836
3821349	Humidity	1,215
3821351	Physical properties testing and inspection equipment, including hardness, strength of materials, thickness, wear, abrasion, and similar testers	34,120
3821398	Other industrial process instruments	138,017
3821400	Motor vehicle indicating instruments, except electric, not specified by kind	310
3821411	Speedometers for motor vehicles (plus)	70,477
3821498	Other motor vehicle indicating instruments, except electric (fuel level, oil pressure, etc.)	
3821600	Other mechanical measuring and controlling instruments, not specified by kind	7,283
3821613	Nuclear radiation detection instruments (including geiger counters, scintillation counters, etc.)	19,922
3821651	Other mechanical measuring instruments	52,986
3821671	Revolution counters	12,530
3822011	Automatic temperature controls, activated by pressure, temperature, level, flow, time, or humidity (including pneumatic controls) of the type principally used as components of air-conditioning, refrigeration and comfort heating or as components of major household appliances	319,855
3831000	Optical instruments and lenses, not specified by kind	21,755
3831011	Photographic and projection lenses and photographic prisms, for sale separately	16,116
3831031	Field glasses, prismatic and nonprismatic; terrestrial and celestial telescopes	4,974
3831051, 3831093, 3831053	Microprojectors and photomicrographic equipment, other optical instruments, lenses, parts, and accessories	45,096
3831071	Optical measuring instruments (refractometers, colorimeters, spectrometers, spectrographs, spectrophotometers, polariscopes, contour projectors, metallographic equipment, etc.)	27,540
3871153	Clock movements, complete but not cased for timepiece use (including electric and spring wound)	4,010
3871161	Electric timing mechanisms, not for timepiece use (including interval timers; mechanisms for parking meters, recording instruments, timing and driving instruments, metronomes, and other devices but excluding time recording and time stamp machines)	29,378
3871165	Spring wound timing mechanisms, not for timepiece use (including interval timers; mechanisms for parking meters, recording instruments, timing and driving instruments, metronomes, and other devices but excluding time recording and time stamp machines)	9,812

*Dear D. R.**:

Hope this finds you well and happy. This month we begin another of our extensive series of instrumentation articles, on the subject of TELEMETERING—indicating, recording or controlling at a distance. We start with two articles which (1) introduce the basic techniques and (2) give basic costs. In the near future you will get a survey of available equipments in this large field of basic instrumentation.

We also continue five more series that you have been reading (we hope) all through this year. One is on *flow instrumentation*, which continues this month with a good, basic article on the theory and operation of rotameters. The second is on *symbolic logic*, which continues this month with a full-adder made up of transistor-diode logic elements. The third series is on *data storage* (*memory*), which continues this month with an article on flexible-disk storage. The fourth series in this issue is on *pressure measurement*, via a survey of precision pressure gauges, (other types of pressure instruments will appear in this series). The fifth series is on *time measurement*, with an article on "Atomic and Molecular Frequency Standards." The series on time instrumentation is drawing to a close—and will have covered all techniques from stop watches to molecular standards.

Everybody knows that the *medical field* should be a good market for technical instruments—but few have dared to invest in it to date. These few, and the entire country, are in for a pleasant surprise. This market is about to erupt dramatically. Instruments Publishing Company, pioneering again, brought out the new trade publication *MEDICAL ELECTRONICS NEWS* in March 1961, reaching more than 35,000 selected workers in the medical and biochemical fields with news about instruments that can solve their problems.

We are overwhelmed with the results—and with cries for help from the medical field. Starting on page 972 you will find some of the many instrument problems facing men in the biomedical field. You, the instrument men and the instrument industry, can solve these literally "vital" problems.

The medical field is at the state of instrument development as was the industrial field 20 years ago. The basic and important variables are being measured, often for the first time. As the importance of these measurements become established (can you think of anything easier to establish?), the measurements will become routine. Every hospital bed and operating table, for example, soon will be instrumented to monitor the important variables in the sick patient. From this, it will be a short step to the console which ties the many measurements together, and the data logging and computing systems that will be needed to handle the mass of "vital" data. This has been the history of the industrial field in the last two decades—it will be the history of the medical field in the next single decade!

We refer the entire instrument industry to that exciting and really new field of our time—the medical field.

Pleasant reading and best regards.

Milt

*Dear Reader.

Survey of Electric Utility Applications of Digital Computers

This Report* lists and describes electric utility applications of digital computers. Contributions have been solicited from every privately-owned or publicly-owned utility system with over 75,000 customer meters.

Programs submitted for this Report have been classified in the following categories. The number following each category title is the number of digital computer studies reported in that category.

Table 1 shows the number of studies run on various computers during each year for the past three years.

Table 1—Summary of Computer Programs by Computers and Years As Reported

Computer	1958	1959	1960	Total
IBM 650	42	31	49	122
IBM 704	11	16	36	63
IBM 705	4	6	3	13
IBM 709			12	12
IBM 7090			11	11
IBM 604	18	17	5	40
IBM 1620			15	15
IBM CPC	1	9	7	17
Royal McBee LGP-30		3	12	15
Bendix G-15	1	7	1	9
Rem. Rand Univac-1		5	3	8
Burroughs E-102	1			1
Datatron 205	5			5
Rem Rand 1101		1		1
Rem. Rand Univac Scientific 1103			1	1
Rem. Rand USS-80			1	1
Rem. Rand USS-90			1	1
Alwac 3E	1	2		3
Total	84	97	157	338

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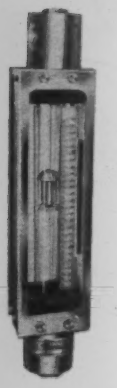

THEORY AND OPERATION OF ROTAMETERS

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Knowledge of basic rotameter theory permits an engineer to select the proper rotameter—or even design a simple inexpensive 2-stage rotameter for high-low flow monitoring.

Nomenclature

- v = fluid velocity through annular orifice section (average), ft/sec
- C = flow coefficient of annular orifice, dimensionless
- W_F = weight of float, pounds
- w_F = specific weight of float material, pounds/ft³
- w_f = specific weight of fluid flowing, pounds/ft³
- g = acceleration of gravity, ft/sec²
- A_F = cross sectional area of greatest diameter of float, ft²
- A_f = flow area or area of annular orifice, ft²
- Q = Flow through rotameter = $v \times A_f$, ft³/sec
- e = height above zero on the tube.
- D_h = inside diameter of tube at height h
- D_F = diameter of head of float
- RN = Reynolds Number = $\rho DV/\mu$, dimensionless
- ρ = density of fluid flowing, slugs/ft³
- D = 4 times the hydraulic radius (area/wetted perimeter), ft
- V = velocity, ft/sec
- μ = absolute viscosity, lb-sec/ft²
- h = head in feet of fluid flowing, feet
- P_1 = upstream pressure, lb/ft²
- P_2 = downstream pressure, lb/ft²
- A_2 = downstream area, ft²
- A_1 = upstream area, ft²
- k = ratio of specific heats, dimensionless

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FLOW OF FLUID in a closed system usually is measured by one of the following five basic types of flowmeter:

1. Variable head (orifice meter, venturi meter, nozzle, or flow tube)
2. Variable area (rotameter)
3. Positive displacement (piston, gear, or "wobble" plate)
4. Turbine (rotating vane or propellor type)
5. Momentum transfer (measurement of force due to change in momentum)

The variable-head meters are the most common and have received the greatest amount of study and space in the literature. However, variable-area meters (rotameters) are becoming more popular because of their greater simplicity and ease of reading. Although many articles in the literature discuss the use of rotameters for specific applications, few have discussed the fundamentals of variable-area meters to help practicing engineers better understand them.

History

The basic equation covering the action of a variable-area annular orifice is the familiar one relating velocity through an aperture to head loss:

$$v = C\sqrt{2gh}^{*} \qquad (1)$$

This relationship was first discovered by *Torricelli* in the early 1600's. It was 150 years later, in 1868, that a Frenchman named *Edmund Chameroy* applied this principle to the variable-area annular orifice formed by a float rising in a tapered metal tube. Chameroy obtained a patent for a device which "consists in the method of determining the volume of fluid flowing with a constant pressure through an opening of variable size by determining in an exact manner, by means of a varied movement, the different changes in the size of the opening through which the liquid or fluid passes."

*In most practical applications of this relationship, head(h) in feet of following fluid is replaced by pressure (p) divided by specific weight of the flowing fluid (w_f): $h = p/w_f$.

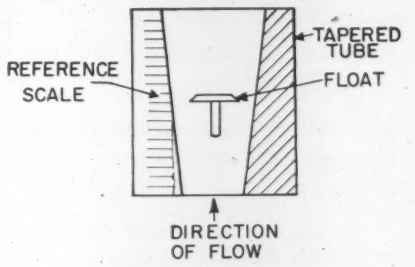


FIG. 1. BASIC rotameter.

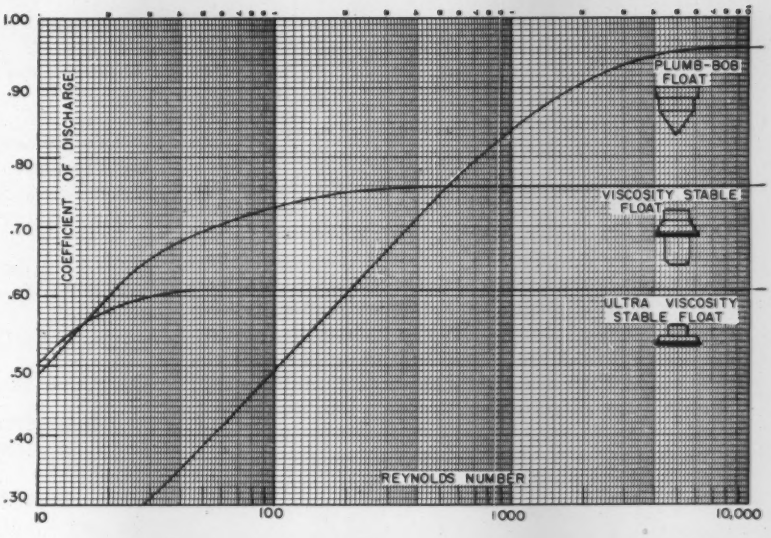


FIG. 2. EFFECT of float shape on flow coefficient (C) in rotameters. (Courtesy Brooks Instruments Co., Inc.)

A few years later an Englishman used a ball in an inclined tapered glass tube to measure flow, and in 1897 *George Joslin*, also an Englishman, received a patent for a metering device consisting of a vertical, tapered glass tube with a float device inside which indicated the rate of flow by the position of the float in the tube—essentially the rotameter as we know it today.

In 1908 *Karl Kuppers* of Germany patented a similar device incorporating a rotating float to prevent binding, and the "rotameter" received the name by which it is still known—even though the floats have long since stopped rotating.

The principal advances since that time have been in developing (1) methods of manufacturing precision-bore tapered glass tubes, and (2) float shapes which give orifice coefficients which are constant over a wide range of Reynolds numbers.

Theory

Fig. 1 shows the essential elements of a rotameter —a float in a tapered tube. If the flow is constant, the float assumes one vertical position and stays there. At this position the sum of the forces acting on the float must equal zero.

The only force acting *downward* on the float is its weight W_F. The forces acting *upward* on the weight are (1) the buoyancy due to the fluid displaced, or $W_F\ (w_t/w_F)$, (2) a force equal to the pressure drop across the float times the cross-sectional area of the head of the float, plus (3) whatever viscous drag there may be on the body of the float. For the moment let us neglect the viscous drag, and consider only the pressure drop across the float and the bouyancy.

The area between the head of the float and the inside of the tube forms an annual orifice. The pressure drop across this orifice ($\Delta p = hw_t$), from Torricelli's theorem (equation 1), equals $v^2w_t/2gC^2$, in lb/ft². If the float is stationary, this pressure times the cross-sectional area of the head of the float (A_F) must exactly equal the weight of the float (W_F) minus the weight of the fluid it displaces—(W_F) (w_t/w_F). Thus:

$$(A_F)(v^2w_t)/2gC^2 = W_F - W_F(w/_tw_F) = W_F(w_F - w_t)/w_F \qquad (2)$$

Hence the velocity v is:

$$v = C\sqrt{2gW_F(w_F - w_t)/A_Fw_Fw_t} \qquad (3)$$

$$Q = A_tC\sqrt{2gW_F(w_F - w_t)/A_Fw_Fw_t} \qquad (4)$$

Equation 4 means that, for constant C, the *flow Q is directly proportional to the flow area* A_t. For a tube with a small taper this gives an *almost linear* relationship between rate of flow and height of float. This is an important point—the relationship between flow area (and rate) and height of the float in the tube is not linear, but for most rotameters it is almost linear, as follows: The bottom of the tapered tube has the same diameter as that of the head of the float (D_F). For a straight taper the inside diameter of the tube at any height (D_e) equals the diameter at the bottom of the tube (D_F) plus a constant times the height e. That is, $D_e = D_F + ke$.

The flow area must equal the area of the inside of the tube minus the area of the head of the float:

$$A_t = (\pi/4)(D_F + ke)^2 - (\pi/4)(D_F^2) = (\pi/4)(2ke\,D_F + k^2e^2) \qquad (5)$$

Equation 5 shows that the relationship between A_t (or Q) and e is not linear because of the nonlinear e^2 term. However, in the actual case, k is small and the relationship is almost linear. For example, assume a 10″ tube length, a float of 0.500″ diameter, and a maximum tube diameter at the upper end of 0.600″. This give $k = 1/100$, and (5) becomes:

$$A_t = (\pi/4)\,(0.02e + 0.0001e^2)$$

For $e = 10''$, which is the maximum, the e^2 term is only 5% of the linear e term.

Returning to equation 4 for flow Q, we see that Q is proportional to orifice area A_f—provided that C remains constant. In early rotameters, the flow coefficient C often was not constant over a wide flow range, especially with a relatively viscous fluid.

Much research has been performed on this phase of the problem in recent years; some results are shown in Fig. 2. The highest flow coefficient (and also the lowest stability) is obtained with the plumb-bob type of float (top in Fig. 2). With this type of float, C becomes constant only at Reynolds number greater than 10,000. Note that the space between the float and the tube is more like a short tube rather than a sharp-edged orifice, and the relatively large effect of viscous drag can be understood.

The viscosity-stable float (Fig. 2, center) shows a constant flow coefficient for values of Reynolds number above 500, and the ultra-viscosity-stable float (Fig. 2, bottom) which closely approximates a shart-edged orifice, shows a constant flow coefficient for Reynolds number larger than 40. Thus we can see that the assumption of constant flow coefficient is true only for Reynold's numbers greater than some minimum which depends on the shape of the float used.

Effect of Specific Weight of Fluid

For flows above this minimum Reynolds number, we can easily determine the difference in flow rate between the liquid for which the rotameter was calibrated and any other liquid we might wish to measure with it. Referring to the flow equation (4), we see that for the purpose of comparing two different flows at the same float position, the factors A_f, C, g, W_F, w_F, and A_F are all constant, and we get:

$$Q_1 = (\text{constants})\sqrt{(w_F - w_f)/w_f} \qquad (6)$$

For a different fluid f2:

$$Q_2 = (\text{same constants})\sqrt{(w_F - w_{f2})/w_{f2}} \qquad (7)$$

The ratio

$$Q_2/Q_1 = \sqrt{(w_F - w_{f2})(w_f)/w_{f2}(w_F - w_f)} \qquad (8)$$

Approximately, then, flow is *inversely* proportional to the square root of the ratio of the specific weights of the fluids, $\sqrt{w_f/w_{f2}}$, the most significant term in equation 8.

Effect of Viscosity

To check the effect of a change of viscosity on the rotameter reading, we need to know (1) the dimensions of the rotameter and the float, and (2) the relationship between C and Reynolds number. Having these, it is then only necessary to calculate the Reynolds number and check a graph to find the change in C.

$RN = \rho DV/\mu$, where D is equal to four times the hydraulic radius (cross-sectional area divided by the wetted perimeter). For an annulus:

$$D = (4)(\pi/4)(D^2_{tube} - D^2_{float})/\pi(D_{tube} + D_{float})$$
$$= (D_{tube} - D_{float}) \qquad (9)$$

This shows that "D" in the Reynolds-number equation equals the *difference in the diameters of the tube and float.*

The best practice is to select a type of float so that the RN for even the lowest rate of flow expected will be larger than the Reynolds number at which the flow coefficient C becomes a constant. If this cannot be done, then the effect of a change in C can be incorporated in the flow equation:

$$Q_2 = Q_1(C_2/C_1)\sqrt{(w_F - w_{f2})w_{f1}/w_{f2}(w_F - w_{f1})} \qquad (10)$$

If the rotameter is being used with an oil whose viscosity changes rapidly with temperature while the specific weight changes slowly, a good approximation would be $Q_2 = Q_1(C_2/C_1)$. This change of viscosity with temperature can be important when measuring the flow of viscous fluids over a range of temperature.

Compressible Gases

The problem of compressible fluid flow (gases) is complex, but the problem is simplified if certain limitations are placed on the meter and the application.

The general equation for compressible-fluid flow through an orifice is similar to the equation for incompressible fluid flow through an orifice with the exception of a compressibility factor Y. The orifice equation is given as:

$$Q = YCA\sqrt{2gh}/\sqrt{1 - (A_2/A_1)^2} \qquad (11)$$

The term $1/\sqrt{1 - (A_2/A_1)^2}$ is called the velocity-of-approach factor and is designated as M. It is usually assumed to be small enough to not seriously affect the calculations throughout the rotameter range. (Note that A_2 increases as flow increases.) This M term has not been adequately investigated for annular orifices to permit an accurate analytical analysis, and it has so far been combined in the value for C. Variation in this factor may, however, help to explain some of the minor discrepancies encountered in the field or laboratory.

The compressibility factor Y, however, can give rise to a relatively large error if it is ignored. The value of Y can be calculated from the equation:

$$Y = \sqrt{\frac{1-(A_2/A_1)^2}{1-(A_2/A_1)^2(p_2/p_1)^2} \times \frac{k}{k-1} \times \left(\frac{p_2}{p_1}\right)^{2/k} \times \frac{1-(p_2/p_1)^{(k-1)/k}}{1-p_2/p_1}}$$

To examine the effect of this factor on the flow reading of a rotameter used for measuring the flow of a gas other than the one for which it was calibrated, we can compare the ratio of the flow factors at any one point of flow. At any one point the *area ratio* is the same for both gases. If the pressure drop across the float is small (less than 10% of the upstream pressure), and the area of the orifice is

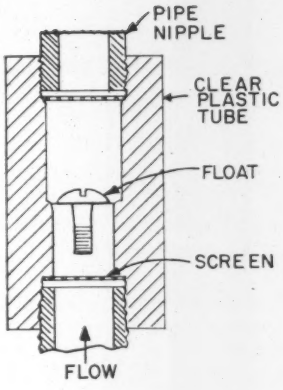


FIG. 3. TWO-STEP flow indicator.

less than 20% of the area of the tube, the difference in the compressibility factors—even considering a change in k—will be less than 1%.

As most gas flows will be at high Reynolds number, there should be no change in the values for C due to change in viscosity.

As the specific weight of a gas is considerably less than the specific weight of a metal, the ratio $(w_F - w_{f2})/(w_F - w_f)$ in equation 8 would nearly equal one. This means that the new flow rate Q_2 (for the different gas 2) would nearly equal:

$$Q_2 = Q_1 \sqrt{w_{f1}/w_{f2}}$$

The effects of a viscosity change and a change in specific weight can be calculated as explained.

There is another change, however, which can be of an even greater magnitude, and this is the change in the area of the annular orifice due to a change in operating temperature. The float is ordinarily of metal, and the tube is usually of glass. Metals have a larger coefficient of thermal expansion than glass, and an austenitic stainless-steel float would expand more than twice as much as a clear borosilicate tube (thermal coefficient of expansion is $9.7 \times 10^{-6}/°F$ for the austenitic stainless and $3.7 \times 10^{-6}/°F$ for clear borosilicate glass). Depending on the dimensions of the system and the temperature differential, this could have an appreciable effect. If operation at any temperature more than a few degrees different from the calibration temperature is contemplated, the effect of the differential coefficients of thermal expansion of float and tube should be checked.

Design of a Simple Two-Step Rotameter

Now that we have examined the theory and understand how a rotameter operates, we can apply this knowledge to selecting or designing a rotameter to fit a specific application.

One application where a tailor-made rotameter may prove more desirable and less expensive than a commercial item is for high-low (two-step) flow measurement, as in measurement of cooling water, where the flow need only be (1) sufficient to cool and (2) not much more. For this type of application a *two-step flow indicator* is ideal because it shows either inadequate flow, adequate flow, or excess flow.

For example, suppose it is desired to maintain a flow between 4 and 4½ gallons per minute. The flow equation (4) is:

$$Q = A_f C \sqrt{2gW_F(w_F - w_f)/A_F w_F w_f} \qquad (4)$$

A sketch of the flow indicator is shown in Fig. 3. The float can be made from a stainless-steel round-head machine screw, obtainable in sizes to ½". For larger sizes, carriage bolts make excellent floats, giving sharp-edged annular orifices. (Such bolts are seldom available in stainless steel and would have to be chrome-plated to guard against corrosion.)

For the shape of float selected, the orifice coefficient would be approximately 0.85. Stainless steel weighs 495 lbs/ft³ and water weighs 62.4 lb/ft³. Substituting these values in the flow equation, with the value of 32.2 ft/sec² for g, equation (4) reduces to:

$$Q = 0.808\, A_f \sqrt{W_F/A_F} \qquad (13)$$

Q will equal 0.00892 ft³/sec for a flow rate of 4 gpm, and 0.01003 ft³/sec for a flow rate of 4½ gpm. If we select a ⅜" round-head machine screw, the head diameter will be close to 0.700", and $A_F = 0.00268$ ft².

If we assume a 1.000" bore, this gives $A_f = 0.00278$ ft² and $W_F = 0.0422$ pound. This will be a machine screw about 1¼" long.

To determine the required larger diameter, we solve for A_f after substituting the value just obtained for W_F in the abbreviated equation (13) for Q. This gives $A_f = 0.00312$ ft², which means a larger diameter of 1.032", which can be obtained by reaming with a 1 1/32"-diameter drill.

The flow indicator should be tested after it is completed. The float may have to be adjusted slightly if the flow required to keep the float in its mid position is different from the desired flow rate. If the actual flow is more than desired, the weight of the float can be reduced by grinding off the end. If the actual flow is less than desired the diameter of the head of the float may be reduced slightly, or a heavier float used.

This series on flow measurement will be continued—Ed.

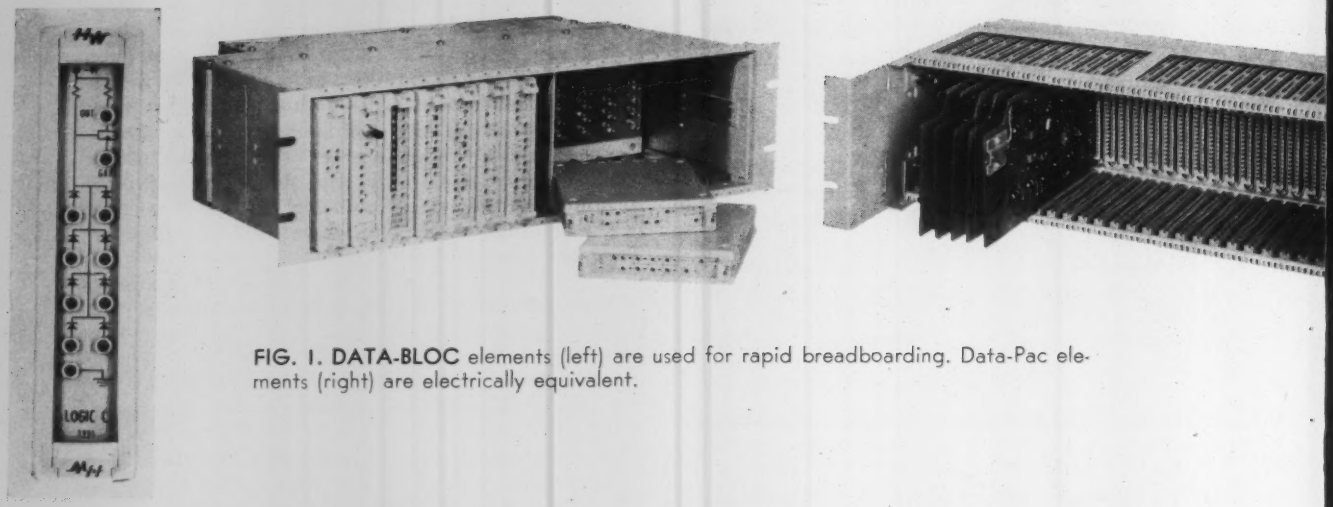


FIG. 1. **DATA-BLOC** elements (left) are used for rapid breadboarding. Data-Pac elements (right) are electrically equivalent.

Data-Bloc and Data-Pac Symbolic Logic

GEORGE ENGMAN, Harvey-Wells Electronics

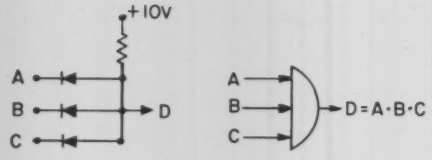


FIG. 2. **DIODE** AND gate. Logic symbol representation is at right. If any input is —4 v, D is —4 v. All inputs must be 0 v (binary 1) for D to be 0 v (binary 1). Logic E unit contains three such AND gates.

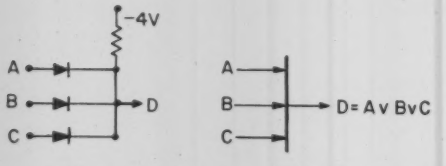


FIG. 3. **OR** gate. If any one input is 0 v (binary 1), the output is 0 v (binary 1). That is, D = A v B v C. Conventional OR gate symbol is shown at right. Logic F unit has 3 such gates.

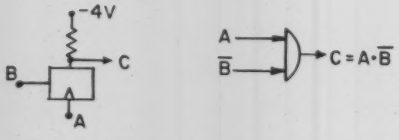


FIG. 4. **TRANSISTOR** inverter-gate. C is binary 1 (0 v) when A is 1 (0 v) and B is 0 (—4 v). That is, C = A·$\overline{B}$. Logic symbol at right illustrates action.

LOGIC building blocks in two package styles (Data-Bloc and Data-Pac) permit rapid breadboarding. The families (Fig. 1) are electrically equivalent and interchangeable. Data-Bloc modules, designed for rapid breadboarding, feature a logic diagram on the front panel. When the breadboard is accomplished, they can be replaced rapidly with the Data-Pac electrical equivalents to produce a final system.

Both use transistors and diodes. The logic signal levels throughout are 0 v for binary 1, and —4 v for binary 0. That is, a 0-volt signal represents binary 1 (or existance); a —4-v signal represents a binary-0 signal.

Diode Logic Gates

Two types of diode gates are used—one for AND (Logic E) and one for OR (Logic F). The logic E unit contains three AND gates, each of which has three inputs, as shown in Fig. 2.

In Fig. 2, if any input is —4-v (binary 0), the diode conducts and the output D will be —4 v (binary 0). Only if all inputs are 0 v (binary 1) can the output D be 0 v (binary 1). This is the AND function:

$$D = A \cdot B \cdot C = 1$$

The Logic F unit contains three OR gates, each of which has three inputs (Fig. 3). In Fig. 3, D will be 1 (0 v) if any one of the inputs is 1 (0 v). That is:

$$D = A \vee B \vee C = 1$$

The outputs of these diode logic gates must be buffered (by inverters) before they are used to perform other functions.

Transistor Logic Elements

Transistor logic elements are inverter-gates (Fig. 4). A must be 0 volts (binary 1) and B must be -4 volts (binary 0) for C to be 0 volts (binary 1). That is:

$$C = 1 = A \cdot \overline{B}$$

Three inverter-gates can be used to make a two-input transistor AND gate (Fig. 5). C is 1 (0 v) only when both A and B are 1 (0 v).

Diode AND logic also can be combined with the transistor-inverter to obtain the AND gate shown in Fig. 6. If D is sufficient (if the affirmative output D is unnecessary), the second inverter-gate can be eliminated in Fig. 6.

The AND function also can be accomplished with a Logic F Type (OR-type) diode-gate followed by an inverter-gate (Fig. 7), if the complements of the inputs are available. The Logic-F element is an OR gate, as explained previously. Inverting the OR output produces the AND function because

$$\overline{\overline{A} \; v \; \overline{B} \; v \; \overline{C}} = A \cdot B \cdot C$$

When a two-input AND gate is sufficient, and the complement of one of inputs is available, a single inverter-gate can be used as shown in Fig. 4. If A is 0 volt (A = 1) and B is −4 v ($\overline{B}$), then C exists. That is, $C = A \cdot \overline{B}$

Exclusive OR

The *exclusive OR* logic function means that A or B must exist, but not both. That is,

$$\begin{aligned} C &= (A \; v \; B) \cdot (\overline{A \cdot B}) \\ &= (A \; v \; B) \cdot (\overline{A} \; v \; \overline{B}) \\ &= A \cdot \overline{B} \; v \; B \cdot \overline{A} \end{aligned}$$

This expression is a common and useful one; for example, it is the sum (S) term for simple addition of two bits. It is also known as the *half sum* because it represents addition without a carry signal from a previous operation. That is, the half-sum is:

$$S_H = A \cdot \overline{B} \; v \; B \cdot \overline{A}$$

Fig. 8 shows two inverter-gates connected to produce the exclusive-OR function. The element on the left produces an output $C = A \cdot \overline{B}$. The element at right produces an output $C = B \cdot \overline{A}$. As either one produces an output:

$$C = A \cdot \overline{B} \; v \; B \cdot \overline{A}$$

Half-Adder

A half-adder adds two binary digits and produces a sum S and a carry C, but there is no provision for a carry (C_p) from a previous stage. The symbolic-logic expressions for the half adder are:

$$\begin{aligned} S &= A \cdot \overline{B} \; v \; B \cdot \overline{A} \\ C &= A \cdot B \end{aligned}$$

Note that the output of an exclusive OR (Fig. 8) provides this sum signal S.

The carry signal (A•B) can be realized by combining the sum signal, (which is already available) with either the A or B signal, as follows:

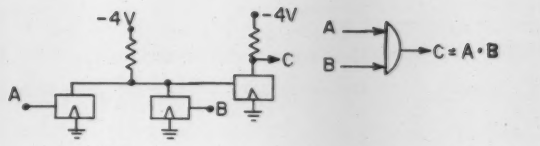


FIG. 5. AND gate comprising three transistor inverter-gates. C is 1 (0 v) only when both A and B are 1 (0 v). That is, $C = A \cdot B$.

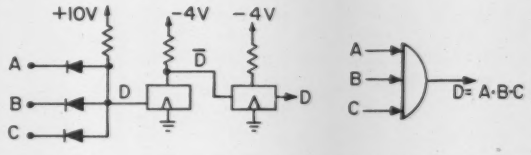


Fig. 6. AND gate formed by diodes is buffered by two transistor inverters.

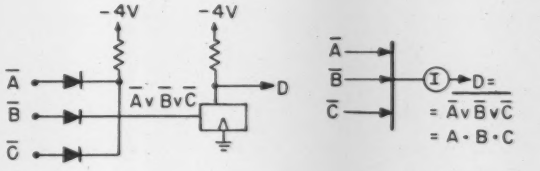


FIG. 7. AND gate formed by using the complement of inputs to an OR gate, and inverting the output. That is, $\overline{A} \; v \; \overline{B} \; v \; \overline{C} = A \cdot B \cdot C$.

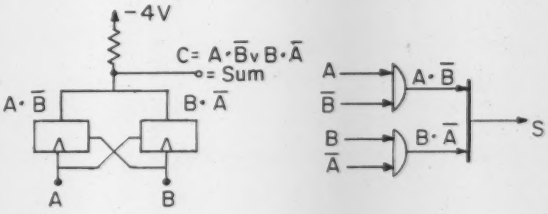


FIG. 8. EXCLUSIVE OR produces an output when either input is present, but not both. This can be expressed $C = A \cdot \overline{B} \; v \; B \cdot \overline{A}$. Two transistor inverter-gates produce this exclusive-OR function.

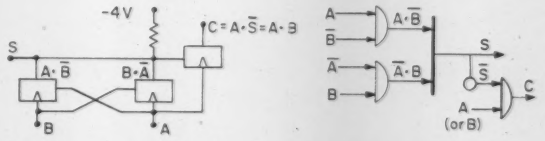


FIG. 9. HALF-ADDER produces a sum S and carry C output. One Logic A unit has three transistors which can be interconnected as shown at left to produce a half-adder. Conventional logic symbols are shown at right.

TABLE 1—Symbolic-logic expressions for the Sum (S) and carry (C) in adding.

Inputs			Output		S exists when	C exists when
A	B	C_p	S	C		
0	0	0	0	0		
0	0	1	1	0	$\bar{A}\cdot\bar{B}\cdot C_p$	
0	1	0	1	0	$\bar{A}\cdot B\cdot\bar{C}_p$	
1	0	0	1	0	$A\cdot\bar{B}\cdot\bar{C}_p$	
0	1	1	0	1		$\bar{A}\cdot B\cdot C_p$
1	0	1	0	1		$A\cdot\bar{B}\cdot C_p$
1	1	0	0	1		$A\cdot B\cdot\bar{C}_p$
1	1	1	1	1	$A\cdot B\cdot C_p$	$A\cdot B\cdot C_p$

$$S = \bar{A}\cdot\bar{B}\cdot C_p \vee \bar{A}\cdot B\cdot\bar{C}_p \vee A\cdot\bar{B}\cdot\bar{C}_p \vee A\cdot B\cdot C_p$$
$$= C_p\cdot(\bar{A}\cdot\bar{B} \vee A\cdot B) \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$C = \bar{A}\cdot B\cdot C_p \vee A\cdot B\cdot C_p \vee A\cdot\bar{B}\cdot C_p \vee A\cdot B\cdot\bar{C}_p$$
$$= A\cdot B\cdot(C_p \vee \bar{C}_p) \vee C_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$= A\cdot B \vee C_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$

$$C = A\cdot\bar{S}$$
$$= A\cdot\overline{(A\cdot\bar{B} \vee B\cdot\bar{A})}$$
$$= A\cdot\overline{(A\cdot\bar{B})}\cdot\overline{(B\cdot\bar{A})}$$
$$= A\cdot(\bar{A} \vee B)\cdot(\bar{B} \vee A)$$
$$= A\cdot(\overline{A\cdot\bar{B}} \vee A\cdot B)$$
$$C = A\cdot B, \text{ because } A\cdot\bar{A} = 0.$$

It can be shown, similarly, that

$$C = B\cdot\bar{S} = A\cdot B$$

Fig. 9 shows the half-adder that gives these sum (S) and carry (C) signals.

Full Adder

Fig. 10 shows a complete adder using two half-adders. A full adder includes a carry input from a previous operation (C_p). The sum and carry digits usually are expressed as shown in Table 1, which is a truth table for binary addition.

The first equation for the sum signal is obvious from the truth table. The second equation for the sum is simply a restatement obtained by factoring out C_p and $\bar{C}_p$. That is,

$$S = \bar{A}\cdot\bar{B}\cdot C_p \vee A\cdot B\cdot C_p \vee \bar{A}\cdot B\cdot\bar{C}_p \vee A\cdot\bar{B}\cdot\bar{C}_p$$
$$= C_p\cdot(\bar{A}\cdot\bar{B} \vee A\cdot B) \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$C_p = A\cdot B \vee B\cdot C_p \vee A\cdot C_p$$
$$= A\cdot B \vee C_p\cdot(A \vee B)$$

Fig. 10 shows a full adder comprising two half-adders.

Referring to the half adder at the right, inputs A and B produce the half sum $(A\cdot\bar{B} \vee B\cdot\bar{A})$ as shown. The inputs to the element at extreme right are (1) the half sum (S_H) and (2) B. It has previously been described (see Fig. 9) that the carry output of a half-adder is:

$$C = B\cdot\bar{S} = A\cdot B$$

This gives the first term in the carry equation.

Referring to the left-hand adder, the inputs to the cross-connected elements are C_p and the half sum $(A\cdot\bar{B} \vee B\cdot\bar{A})$. The output is then the "exclusive OR" of the two inputs. That is,

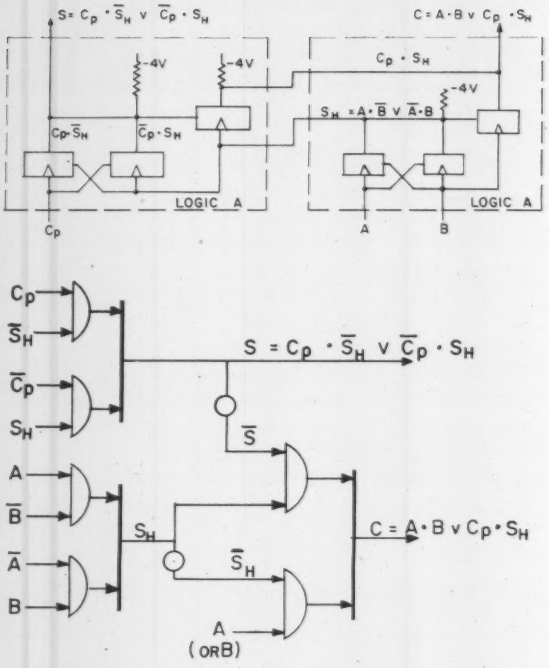


FIG. 10. TWO Logic A units (half-adders) can be linked as a full adder which can handle a carry bit C_p from a previous add operation.

$$S = C_p\cdot\bar{S}_H \vee \bar{C}_p\cdot S_H$$
$$= C_p\cdot\overline{(A\cdot\bar{B} \vee B\cdot\bar{A})} \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$= C_p\cdot(\overline{A\cdot\bar{B}}\cdot\overline{B\cdot\bar{A}}) \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$= C_p\cdot(\bar{A} \vee B)\cdot(\bar{B} \vee A) \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$
$$= C_p\cdot(A\cdot B \vee \bar{A}\cdot\bar{B}) \vee \bar{C}_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$

This is the required sum signal, as shown in Table 1.

To obtain the last term of the carry signal, note that inputs to the third element in the left-hand adder are the sum signal and the half-sum signal (S_H).

This produces the required output as follows:

$$C = (\text{half-sum})\cdot(\bar{S})$$

In Fig. 9 it was shown that the output of the right-hand transistor equals the AND product of the A and B inputs of the left-hand transistors. That is, $C = A\cdot\bar{S} = A\cdot B$

Applying this same logic to the left-hand half-adder in Fig. 10, we obtain:

$$C = (\text{Half-sum})\cdot(\bar{S})$$
$$= C_p\cdot(\text{Half-sum})$$
$$= C_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$

The right-hand half adder in Fig. 10 already provided:

$$C = A\cdot B$$

Therefore the circuit produces:

$$C = A\cdot B \vee C_p\cdot(A\cdot\bar{B} \vee B\cdot\bar{A})$$

This satisfied the requirements for a carry signal, as stated in Table 1.

Flexible-Disk Storage

ROBERT J. PEARSON
Laboratory For Electronics, Inc.

A flexible-disk magnetic recorder maintains specified head spacing, regardless of vibration.

A flexible-disk magnetic recorder (Fig. 1) has several important advantages. Separations from the headplate of 1 mil or less are readily obtainable without additional peripheral equipment. There is almost complete immunity from shock and vibration because the disk is flexible and does not readily transmit axial movements of the shaft with respect to the headplate. As the disk is light, there is no need for any special procedure or operating sequence when accelerating up to speed or decelerating, even under shock and vibration conditions. The flexible-disk recording medium does not wear when it comes in contact with the headplate during start and stop operation. Over three thousand start and stop cycles have been applied to a test device without any indication of wear on the heads or on the magnetic coating of the disk.

The basic units consist of single disks of thin, flexible, instrumentation-grade Mylar magnetic recording tape mounted on a shaft which spins the disk above a smooth headplate in which read/write heads are imbedded flush with the surface.

In the non-operating condition, the flexible disk is limp and rests against the backplate. When the drive shaft is rotated, the disk tends to straighten out under the action of centrifugal force and lifts away from the stabilizing plate. A circumferential velocity is imparted to the fluid in the space between the disk and stabilizing plate by viscous friction. This circumferential velocity gives rise to a centrifugal force on the fluid and a resulting radial velocity as the air moves out from the under the disk. These fluid velocities exhaust the air and reduce the pressure in the separation gap between the rotating disk and the plate. The pressure acting on the open or atmospheric side of the disk forces the disk down. The disk deflection is countered by its own centrifugal and curvature forces in the disk material. The equilibrium operating condition exists as a balance of the pressure forces generated by the fluid flow together with the centrifugal and curvature forces in the disk. A typical radial section through a spinning disk is shown in Fig. 2.

Head-disk velocity varies with radius. The flex-

FIG. 1. **BERNOULLI DISK** recorder.

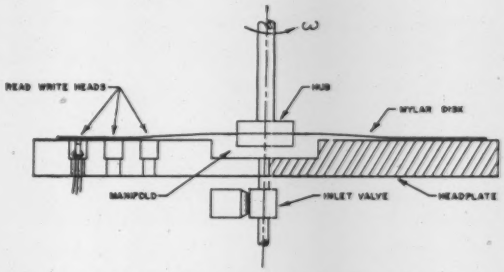


FIG. 2. **PARTIAL SECTION** of the flexible-disk device.

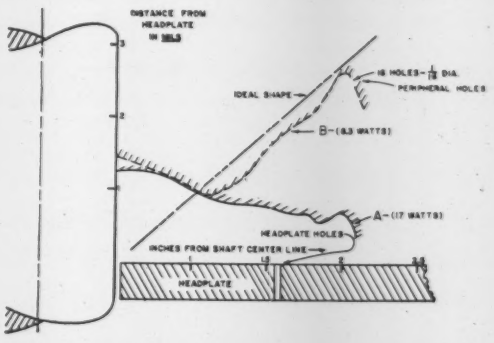


FIG. 3. **FLEXIBLE DISK** contours and motor powers, with and without holes in headplate and disk periphery. Dotted line is ideal curve for constant resolution of all tracks. (Separation is exaggerated, compared with radial coordinate.)

ible disk provides opportunity for compensation of the reduction in wavelength as the track radius gets smaller. If the disk-to-headplate separation is increased with radius, and the recording head gaps are similarly increased, it is possible to achieve a constant resolution for all tracks. Fig. 3 is drawn from actual test results made after drilling small-diameter holes in the headplate and in the disk periphery. The disk-to-plate separation approaches the required contour over the working area. Also less drive power is needed.

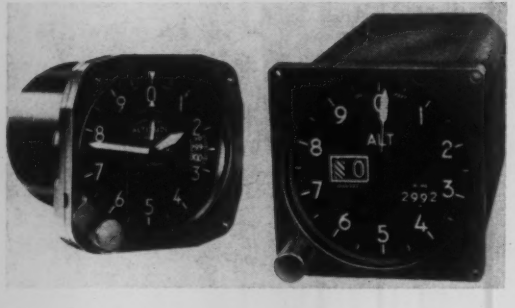
Changes in capacity of any model Bernoulli disk rotating storage device can be implemented in the field. In the BD-500 series, for example, a basic information storage capacity of 500,000 bits can be doubled to one-million bits by adding a second disk and head assembly to the original shaft with two simple set screws. All models may be panel or deck mounted in any orientation and are available as bench units.

Five series of Bernoulli disks are available: BD-10 Series—25,000 to 50,000 bit capacity in 0.09 cubic feet; BD-40 Series—40,000 to 160,000 bit capacity in 0.21 cubic feet; BD-100 Series—100,000 to 400,000 bit capacity in 0.33 cubic feet, BD-200 Series—200,000 to 800,000 bit capacity in 0.66 cubic feet; BD-500 Series—500,000 to two-million bit capacity in 2.36 cubic feet. All measurements include electronics.

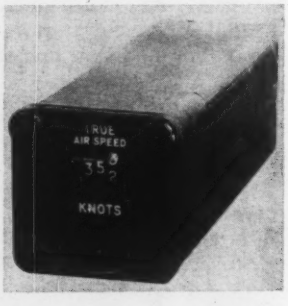
Other specificatons of a typical unit, the Model BD-103 (Fig. 1) are as follows:

Storage capacity is 100,000 bits (max): Bits per track—1000 to 3000: Bit rate is 30 to 400 kc. Typical track layout has 40 total tracks, including 32 data storage tracks, 3 spare tracks, 3 clock and timing tracks, 2 register tracks. Number of registers is 4; register length is 32 bits; register adjustment is ±3 bits; Disk speed is 1800 to 8000 rpm; induction or synchronous motors are available.

Digital Readout



← **FIG. 1. OLDER ALTIMETER** (left), with three overlapping pointers, required pilot to calculate altitude by combining readings. New model (right) provides immediate readout by means of drum-type counter.



→ **FIG. 2. TRUE AIRSPEED** indicator.

AT MACH 0.9, a jet pilot has no time to compute true airspeed. In five seconds, the ship has shot forward a mile. For this reason the trend in aircraft instruments is to direct readout indicators for instant presentation of crucial data to the pilot. One leading instrument maker (the Kollsman Instrument Corp., Elmhurst, N. Y.), reports that its use of direct readouts has increased nearly 60% in 10 years.

Kollsman now uses direct readout on every instrument in its line of navigational equipment, and is replacing many of the pointers and bands on its line of flight instruments with drum-type counters.

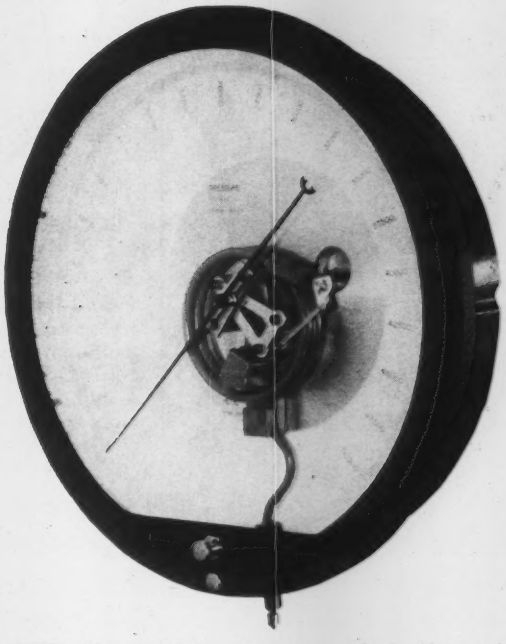
Altimeters

Until recently, altimeters were only made with three overlapping pointers on the dial (Fig. 1)—a long pointer to indicate hundreds, a broad pointer to indicate thousands, and a third short pointer to indicate tens of thousands, all in feet of altitude. However, as shown at the right in Fig. 1, a new low-inertia low-friction counter now shows the pilot his altitude, in thousands of feet, at a quick glance. Only one pointer appears on the face of the instrument, and this indicates more sensitive readings in hundreds of feet. An internal-pinion drum-type counter is used in the altimeter. Similar counters (manufactured by Veeder-Root Incorporated, Hartford, Conn.) are used in barometric setting indicators, thrustmeters (perhaps the key instrument for proper performance of jet engines), true airspeed indicators (Fig. 2), etc.

Kollsman and Veeder-Root design engineers combined forces in developing the units that are now standard equipment. Prior to assembly, every component is thoroughly inspected. A check-off system helps insure 100% quality control. Before the instrument is approved for use, it is subjected to an extensive "seasoning" and pre-calibration process, including temperature conditions over a range from −65° C to 75° C (in some cases above 100° C).

Precision Pressure Gauges

Precision test gauges now can be used instead of dead-weight testers where accuracy of 0.1-0.5% is required. This review describes available precision test gauges of the bourdon and capsule type, and their many unique features.



HEISE offers 100,000-psi gauge with 0.1% accuracy, temperature compensated.

GAUGES with accuracy of 0.5% or better (better than the 1% grade AA ASA accuracy) feature special materials, balanced movements, and special calibration and compensation techniques. Production often is to customer order.

The common transducer is the bourdon tube (C-shaped or helical) or capsule.

Features to be found in these high-accuracy test gauges include:

A. A bimetal strip that varies the pivot-arm connection to effect temperature compensation.

B. Mirror ring, split pointer, or raised dial to avoid parallax error.

C. A helicoid movement using a helical-cut slot on the pointer armature to produce a gearless mechanical transmission element.

D. Individually drawn calibration marks.

E. Dial marks grouped on tabs that can be repositioned for recalibration.

F. Major marks on an inner circle and subdivisions on an outer circle for easy reading.

G. A 360° dial establishing the zero and full scale at the same point, which is in a vertical straight line with the pointer pivot and half-scale point. Bourdon-tube nonlinearity then can be compensated simply by shifting the dial vertically so that its center does not coincide with the pointer pivot.

H. Dials with a rack on a sector of the dial driven by a pinion to preset the dial to, say, ambient air pressure.

I. Bourdon-tube tip bleeders to flush the tube.

J. Restoring calibration by readjusting the "traveling angle" geometry of the linkage.

K. Gauge that rotates the pointer two revolutions for full scale, providing a 45" scale on an 8½" dial.

L. Dial marks whose width is the gauge tolerance. When calibrating, the gauge is in tolerance as long as the pointer tip overlaps the mark.

M. Portable calibration sets.

ASTRA Corporation

Astragauge (Fig. 1) uses a 316 SS bourdon of the helical type fastened at one end to the pressure connection socket and the other end to a pinion. Motion is transmitted from the pinion through an arm to a knife edge attached to the movement. This knife edge is adjustable from the outside of the case to change the range of the instrument by changing the lever multiplication. This gauge is calibrated and checked to ¼% accuracy of full range at a minimum of five points before shipment. Twelve Ranges are available to 100,000 psig, all with 316 SS sockets and elements. Removal of the bezel,

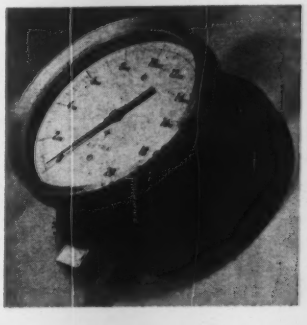


FIG. 1. ASTRAGAUGE

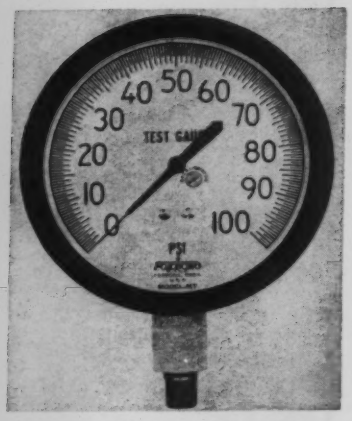


FIG. 2. **FOXBORO** MT has 0.25% accuracy.

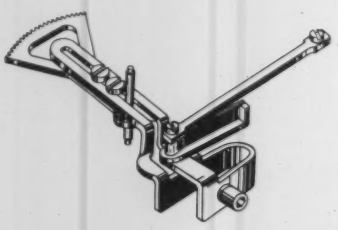
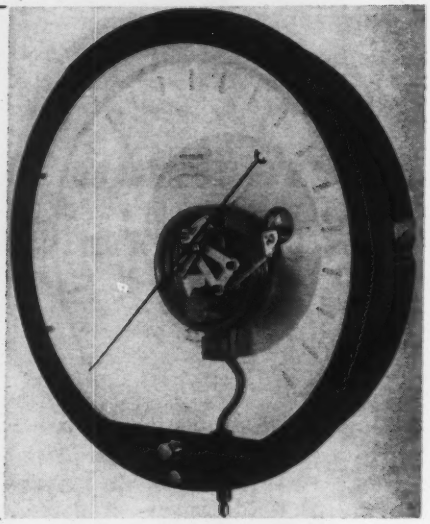


FIG. 3. **HEISE** Precision Gauge with transparent display dial to reveal multi-turn bourdon and movement. **MICRO-SLIDE** adjustment varies length between pivot and junction with linkage. Bi-metal strip provides thermal compensation. Accuracy of 0.1% to 100,000 psi is offered.



safety glass front, pointer, and dial provides access to the movement.

Access to the bourdon tube is accomplished by removing the aluminum snap ring and then the teflon back. This back cover cannot fly off in the event of explosive failure of the bourdon tube. Removal of the bourdon end cap is provided for flushing and cleaning.

The Foxboro Company

Model MT 4½″ Test Gauge (Fig. 2) is available in sixteen ranges, from 0-30″ Hg vacuum to 0-10,000 psig. Accuracy is to within ±0.25% of full scale value. A twin-tip pointer is furnished to avoid parallax errors. Ranges up to 0-600 psig are standard with copper-alloy Bourdon tubes with brass tip and socket and with bronze-bushed movement. Ranges 0-800 psig and over are standard with 4130 alloy steel bourdon tube with alloy steel tip and socket, and with hardened stainless steel and "K" Monel alloy movement.

Heise Bourdon Tube Co., Inc.

Heise precision gauges (Fig. 3) are accurate to 0.1% of full-scale reading throughout the entire 270° dial. Ranges are from 0-15 psig to 0-100,000 psig. Hysteresis is not greater than 0.1% of full-scale reading after application of maximum scale pressure.

Each gauge is critically tested before shipment and a certified copy of the test results is supplied with the gauge. Dial sizes are 8½″, 12″ and 16″ for pressure ranges from 0-15 psig to 0-30,000 psig, and 12″ or 16″ for pressure ranges above 0-30,000 psig and up to 0-100,000 psig.

The dial is supported at the center only by the dial pivot, which is mounted on the dial support plate. The dial mounting is independent of the case or bezel. This design guarantees concentricity of the dial and movement to maintain maximum accuracy. The dial can be rotated 30° to adjust dial zero to atmospheric pressure or similar bench mark.

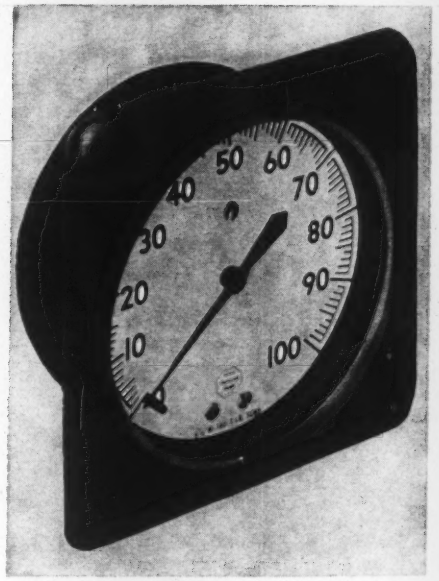
Highly specialized dividing machine is used to individually engrave each graduation to the pressure gradient of its own gauge mechanism. The graduations are cut to a precision reading.

Recalibration, when required, is simplified by a patented feature with which precision adjustment may be made in the effective length of the sector slide. The micrometer screw attached to the slide (Fig. 3) can be adjusted to as little as 0.0005″ where minute corrections are necessary. A preloaded spring tends to protect the calibration setting against accidental shock.

The *thermal compensator* (Fig. 3) comprises a bimetal bar forming part of the linkage between the moving end of the bourdon tube and the gear segment slide of the gauge movement. Deflection of the bimetal bar resulting from a change in ambient temperature causes the point at which motion is imparted to the slide to move in an arc so as to change both the angular position and the effective length of the slide. This compensate for (1) thermal growth of linkage members, and (2) variations in modulus of elasticity of the bourdon tube. Direct readings are accurate to 0.1% on pressures up to 100,000 psig with temperature varying from −25 to +125°F.

Features include (1) integral movement, (2) external bleeder, (3) weldless, heat-treated stainless-steel bourdon tube. (4) choice of wide range (0-15 to 0-100,000 psig) with 0.1% full-scale accuracy.

Special features available include (1) double scales, (2) peak load indicator, (3) slotted link, and (4) potentiometer equipped.



Helicoid Gage Division
American Chain & Cable Co., Inc.

The Helicoid Movement (see Fig. 4) features no gears or teeth to wear out. The rolling action of the graphited Bakelite cam facing across the stainless-steel roller surface in the Helicoid movement always tends to keep the contact point clean and smooth.

The cam is made of corrosion-resistant metal.

The External Pointer adjuster raises or lowers the roller. Micrometer adjustments of the pointer on Helicoid gauges are therefore simple. This type of adjuster cannot be jarred out of position. It is not necessary to remove the glass in order to adjust the pointer.

If a gage might be subjected to pressures beyond the maximum dial graduation, a Helicoid gauge with a right-hand roller movement should be used because the cam releases from the roller well beyond the maximum dial pressure.

If a gauge is to be subjected to vacuum, or sudden reductions in pressure (as in hydraulic press service), a left-hand roller movement is used because the cam releases from the roller at zero. This prevents the gauge pointer from slamming against the dial stop pin. It is the only gauge thus protected for vacuum. A compound gauge should be used for indicating both pressure and vacuum.

Test gauge dial sizes are 4½", 6" and 8½". Anti-parallax mirror is available in 6" size only. Accuracy can be ±½ of 1% or ±¼ of 1%.

Manning, Maxwell & Moore, Inc.

Ashcroft Laboratory Test Gauges (Fig. 5) provide an accuracy of 0.25%. The accented graduations have a true width equivalent to 0.25% tolerance, which permits quick and accurate checking—if the pointer tip is not within the area of the graduation at any specific test pressure, the gauge is not within the specified accuracy. The dials have an integral

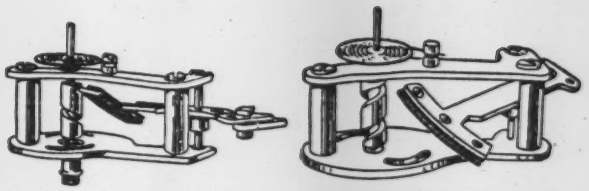


FIG. 4. HELICOID movement eliminates gears. Gauge is shown at left; left-hand and right-hand roller movements are shown above.

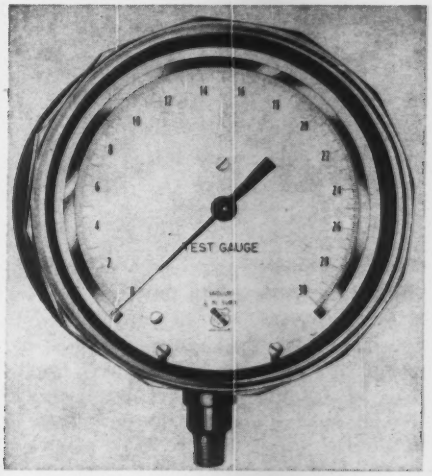


FIG. 5. MANNING, MAXWELL & MOORE Type 1082 Laboratory Test Gauge features 0.25% accuracy; accented graduations with a true width equivalent of 0.25% tolerance, permitting quick and accurate check by user; ranges to 100,000 psi. Pocket (3") Test Gauges with 0.5% accuracy also are offered.

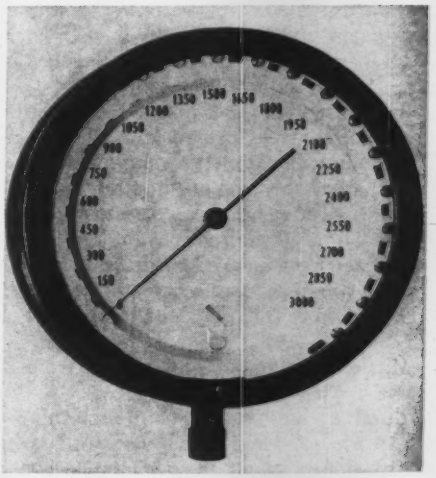


FIG. 6. MANNING, MAXWELL & MOORE MaxiTest Type 1080 Test Gauge features graduations on tabs that can be positioned.

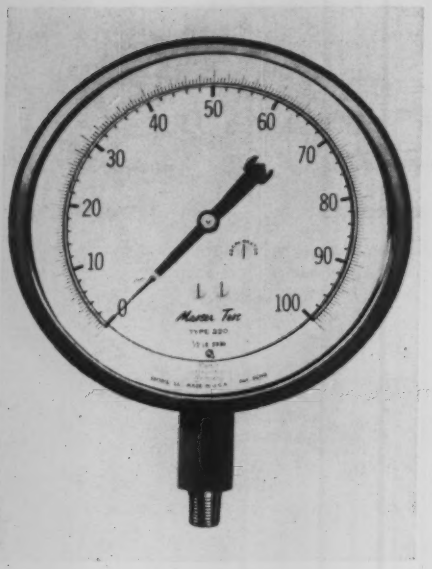


FIG. 7. MARSH "Master Test" Gauge features "read-easy" dial and twin-tip pointer.

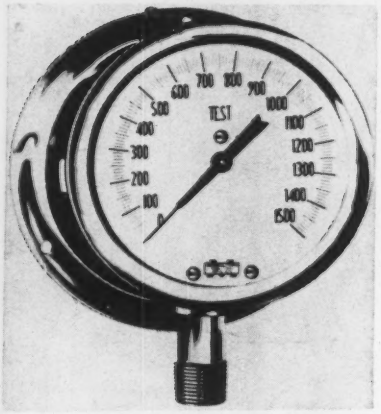


FIG. 8. MARSHALLTOWN Standard Test Gauge.

band of mirror-polished stainless steel under the tip of the pointer to reflect the pointer.

A specially heat-treated phosphor bronze bourdon tube is used for pressure ranges to 600 psig. For ranges over 600 psig (to 10,000 psig) the tube is heat-treated beryllium copper, which has minimum hysteresis effect. All bourdon tubes are silver brazed at socket and tip and stress relieved after brazing.

Movement is bronze and is mounted on the socket independent of the case. Dial sizes are 4½", 6" and 8½". Pointer is balanced with the tip twisted on edge for ease of reading to the smallest subdivision.

The Ashcroft Maxitest Gauge Type 1180 (Fig. 6) combines all of the features essential for maximum accuracy and ease of reading; it is recommended and particularly suited for use as a master reference gauge to check the accuracy and to calibrate test gauges, receiver gauges, pressure transmitters, etc.

In place of the usual printed dial graduations, the Maxitest gauge dial has specially-developed metal tabs positioned near the outer circumference of the dial at major dial graduation points (Fig. 6). Each tab can be individually and precisely set so that the pressure reading at each point is exact. The resulting accuracy, at any dial tab reading, will be not less than that of the calibration standard (0.1% in the case of a deadweight gauge tester). There are no intermediate dial graduations. In addition, each tab is designed and marked to indicate any deviation from a standard reading, in terms of percent of total error, from 0.25 to 1% of total dial graduation.

The Maxitest gauge is supplied in a front-flange case.

The durable, lightweight aluminum alloy case and the two-level "Maxivision" dial are finished in contrasting shades of green to minimize eye strain and increase readability. The dial and pointer design eliminates parallax error. They are positioned so that the tip of the pointer is on the same level and adjacent to the movable tab. A blank dial is available to permit setting of tabs according to user's preference.

Marsh Instrument Company

Marsh Master Test Gauges (Fig. 7) are available in 30 ranges, for extreme pressures of 0 to 30,000 psig to sensitive vacuum readings of 0 to 30" of mercury or 0 to 15 psig. Accuracy is ±0.25% of maximum dial reading. Standard construction is with bourdon tube of 4130 alloy steel with alloy steel tip and socket, but other materials can be specified.

The Marsh "Read Easy" dial shows major graduations on the inner arc and fine graduations on the outer arc. The operator obtains an accurate reading easily—no optical blur from too-close graduation marks.

The most common error in dial reading occurs when the operator reads the gauge from an angle. The "Twin-tip" pointer helps to eliminate this by having two tips, one directly beneath the other. In order to obtain a correct reading, both tips must be lined up so that only one tip is visible to the observer. A mirror dial and a non-parallax dial are alternate options.

The Marshalloy Safecase provides safety from unexpected, explosive over-pressure. A steel plate is welded into the case directly behind the gauge dial to protect the face. A thin stainless-steel safe plate fits snugly over the entire back of the case and opens out to release explosive force. Two holding screws keep the safe plate from being detached during a blowout. Construction is dust and moisture proof.

To recalibrate simply relieve all pressure and turn the recalibrator screw until the pointer rests at zero. Another method is to feed the gauge known pressure and turn the recalibrator screw until the pointer indicates the correct pressure. The thick-

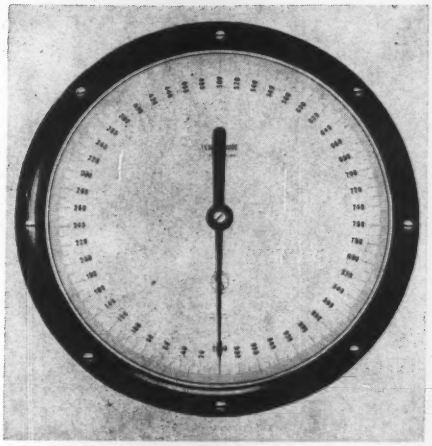


FIG. 9. MARTIN-DECKER Precision Test Gauge has 360° dial.

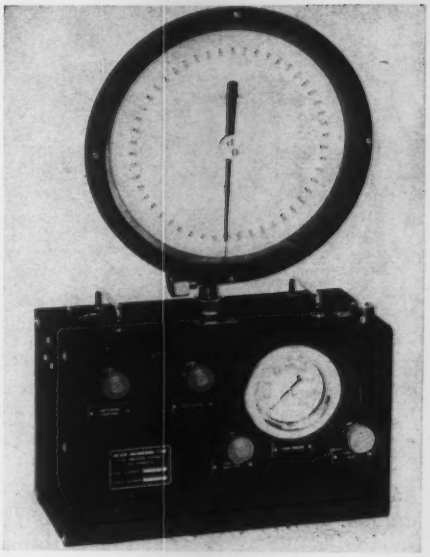


FIG. 10. MARTIN-DECKER Field Calibrator uses tank charged with dry nitrogen.

ness of the line indicating the major graduation is the permissible tolerance.

Marshalltown Manufacturing Company

Marshalltown's Standard Test Gauge (Fig. 8) is available in nineteen ranges, from 0-15 to 0-10,000 psig. Bourdon tube is trumpet brass for pressure ranges up to and including 1000 psig and bored tool steel for pressures over 1000 psig. Tubes are specially made and seasoned for maximum sensitivity. Movement is brass for ranges up to 1000 psig and monel for ranges over 1000 psig.. Accuracy is 0.5% of full scale. Dial sizes are 3½", 4½", 6", 8½" and 12".

Martin-Decker Corporation

Martin-Decker Precision Test Gauge (Fig. 9) employs a 360° linear dial with the movement calibrated to the dial with an accuracy of ±0.15% or better. An important feature of the 360° movement is simplicity of calibration. The movement can be recalibrated easily to any stock dial of the same range.

The 360° dial offers greater readability in a smaller package. The 8½", 360° dial offers a scale length equal to that of a conventional 12" dial calibrated through only 270°—the 12", 360° dial matches in scale length a conventional 16" dial.

The newest and most unusual offering by Martin-Decker is its 24" Precision Test Gauge with a 75" scale length.

The bourdon tube is designed to move the tip along a path proportional to pressure with negligible curvature for the travel employed. The quadrant link can be aligned with the path at mid-scale. For an equal increment of pressure on either side of mid-scale, the pointer will have an equal amount of error, but of opposite sign. Since zero, mid-scale and full scale are all in a straight line on the dial, the dial can be shifted vertically, thus eliminating errors between zero and mid-scale, and between mid-scale and full scale—without affecting the accuracy at zero, mid-scale and full scale.

The standard Martin-Decker Precision Test Gauge employs a bourdon tube made of Ni-Span C to maintain calibration under varying ambient or media temperatures. Tube tip bleed is furnished. Special tube materials also are available.

Ranges are from 0-60 psig to 0-15,000 psig. Scale can be rotated and has mirror ring.

A precision calibrator (Fig. 10) can be used for field or line calibration of gauges and transducers. A storage tank in the unit is charged with dry nitrogen prior to use. Four precision gauges are furnished and their spans can be selected from nine alternatives, varying from 0-60 psig to 0-6000 psig.

Seegers Instrument Co., Inc.

Seegers Standards gauges (Fig. 11) use an 8:1 movement ratio for pressure from 15 psig; from 150 psig (to 10,000 psig) a 12:1 ratio movement is used—to avoid excess mechanical multiplication. All bourdon tubes are formed to an 8"-diameter arc. Pinions are centered with respect to the bourdon tube, as well as the dial, to eliminate mechanical off-center error and to facilitate recalibration for a true zero adjust.

Seegers gauges can withstand 100% over-pressure without calibration shift, and 200% over-pressure without permanent damage to the bourdon tube. Tube tip bleeders are standard. Dial increments are of equal spacing, with the bourdon tube calibrated to the dial. The visible-center dial enables the operator to inspect the gauge movement.

After some use a gauge pointer may indicate other than zero at zero pressure. In a majority of instances this is caused by a radius shift in the tube (Fig. 11). No matter where the dial is positioned, the starting angle between the sector and

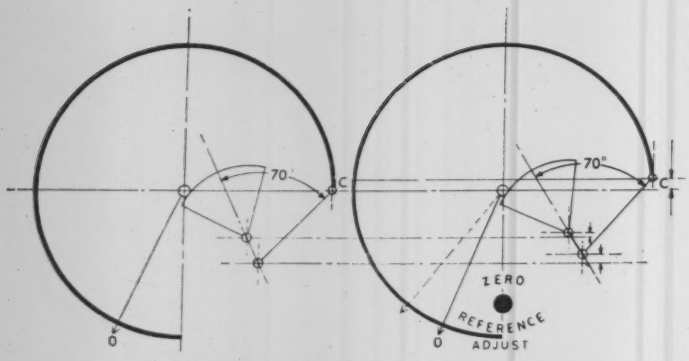


FIG. 11. SEEGERS Standards gauges feature "zero reference adjust." Recalibration to zero is accomplished by shifting sector pivot so that both pointer zero and 70° traveling angle are restored to proper values.

link has been distorted. Rotating the dial merely aggravates the condition. However, if the original starting angle is re-established, the pointer will again fall to zero.

In Seegers units the dial is fixed in a permanent position, and the zero is used as a reference point. The pointer always can be returned to the zero reference point by shifting the sector pivot. Thus recalibration reestablishes the original starting angle between the sector and bourdon link. This feature is known as "zero reference adjust."

United States Gauge Division American Machine and Metals, Inc.

Guaranteed accuracy of USG Test Gauges (Fig. 12) is 0.2% of scale range for first 20% of the range, and 0.5% of indicated reading for the remainder of the dial range. A certificate of calibration is furnished with every test gauge. Standard ASA Dial Ranges from 0-15 psig to 0-20,000 psig, also higher ranges and non-standard ranges can be furnished. Available on request are a limited number of suppressed-range test gauges using a slotted or spring-loaded link and a scale showing only the upper portion of the total pressure range of the bourdon tube. All test gauges are built on the customer's order.

Tips have bleed valves to purge air on solid-filled systems. Tubes have high and low stop for over- or under-range protection of tube and movement.

External self-locking adjustment is provided to position the dial through an arc of 20° to permit zero adjustment compensation for column height or preloading. Mirrored anti-parallax dials can be furnished. Dial sizes are 12″ and 16″.

Test gauges with 4½″, 6″ and 8″ dials and temperature-compensated test gauges use a bourdon tube made of Ni-Span C. A patented adjustable-link mechanism permits the use of metal having various thermal expansion rates to complement each other, resulting in linear correction. These gauges provide accuracies of +0.25% at room temperature and ±0.375% from −40° to 125°F in pressure ranges of 0-160 and 0-600 psig. Accuracies of ±0.50% at room temperature and ±0.75% from −40° to 125°F are provided in ranges from 0-5,000 to 0-10,000 psig.

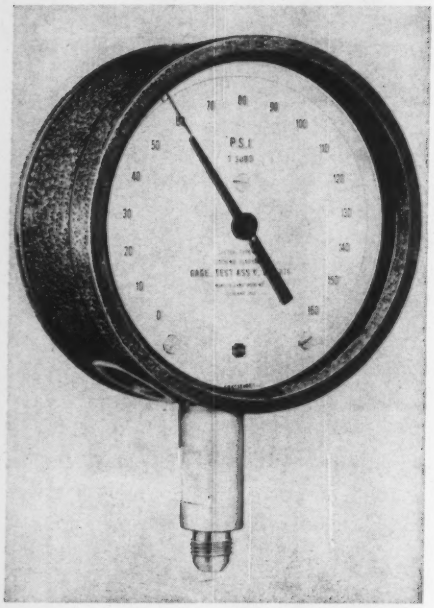


FIG. 12. UNITED STATES Gauge Division Test Gauge.

Wallace & Tiernan Inc.

The pressure-sensitive element of the Wallace & Tiernan Precision (0.1% accuracy) Dial Manometer Type FA-145 (Fig. 13) uses a precision beryllium-copper capsule. A friction-free movement, using flexure pivots, transmits motion of the pressure-sensitive element of the pointer shaft. The only rotating part is the pointer shaft, which is pivoted in a jewel bearing and guided by a hardened sleeve. The mechanism is housed in a pressure-tight aluminum case designed for a maximum static pressure of 35 psig.

The instrument can be supplied for any range from 0-120 inches of water to 0-300 inches of mercury. Gauge pressure, vacuum, and differential pressure can be measured. Every dial manometer scale is custom calibrated against a precision-bore liquid column at approximately 100 points. This eliminates any need for a scale correction chart.

Dial diameter is 8.5″. The instrument pointer covers the range in two revolutions, yielding a scale length of about 45″. A revolution counter is provided so that the observer can tell at a glance whether to read the inner or outer ring. A mirrored ring eliminates parallax errors in reading.

The instrument responds to pressure changes as little as one part in 10,000 of the scale range with an accuracy of one part in 1000. Temperature correction is only 0.375% of the indicated reading per 10 Centigrade degrees. The standard calibration temperature is 25° Centigrade. Hysteresis effect has been reduced to one part in 1000 of full range, except as noted.

The W&T Precision Aneroid Manometer Type FA-129 is used as a secondary calibrating standard

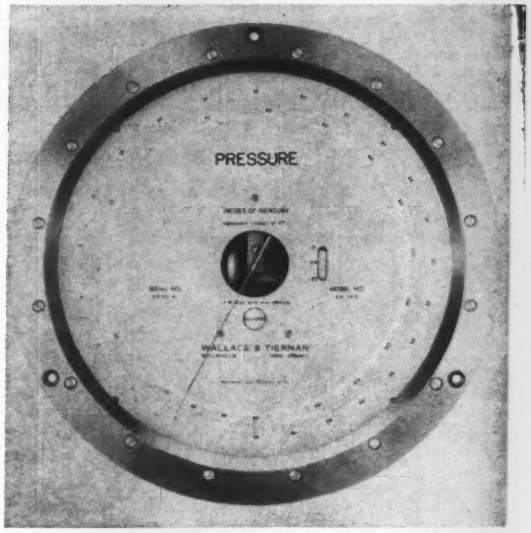


FIG. 13. WALLACE & TIERNAN Precision Dial Manometer Type FA-145 uses flexure-pivot movement.

FIG. 14. WALLACE & TIERNAN Portable Precision Calibrator for field checking pneumatic controls also can measure pressure difference between two signals.

for absolute pressure work, such as for calibrating and testing radiosondes, baroswitches, altitude controllers, and pressure and temperature switches. It also has 8.5″-dia two-revolution dial. All temperature-compensated models use Ni-Span-C capsules. No corrections need be applied for atmospheric pressure of gravity when using the Precision Aneroid Manometer. All models have a sensitivity of 1 part in 10,000. Accuracy is 0.1% of full scale. Five ranges are available from 0 to 31.5″ Hg to 0 to 100″ Hg absolute pressure.

Bourdon tube gauges Types FA-233 and FA-234 (also 8.5″-diameter two-revolution dial) provide ranges from 0 to 50 psia, to 0 to 500 psia. Accuracy is guaranteed to 0.1%. Two bourdon tubes are connected by a ratio linkage. The reference tube is evacuated to absolute zero and sealed. The pressure to be measured is applied to the second tube, enabling the user to read directly in absolute pressure.

Because atmospheric changes of ± 5″ Hg will not cause the instrument to go out of tolerance, the need for barometric compensation is eliminated. This instrument is excellent where low-volume elements are needed as internal volume is only 8 cc. Gauge Pressure Indicator, FA-234 Series contains one bourdon tube, which is referenced against atmospheric pressure.

The Precision Pneumatic Calibrator Series FA-235 (Fig. 14) is an accurate portable instrument designed primarily for field checking pneumatic controls in the 3-15 psig range. An over-pressure-relief valve on the panel protects the capsule side of the instrument and any relief action is readily observed by the operator. The valve re-seals merely by dropping pressure to about 10 psi. The capsule side of the instrument also is protected by a flow restrictor. Sudden pressure changes, even those of full-scale magnitude, cannot damage the instrument mechanism.

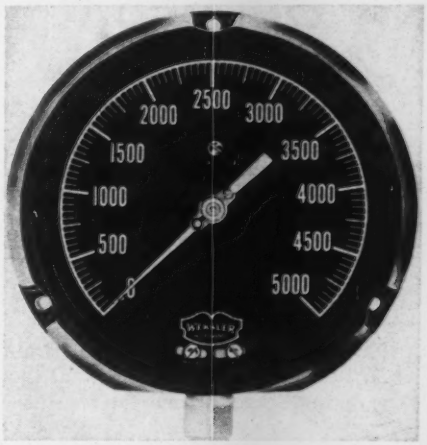
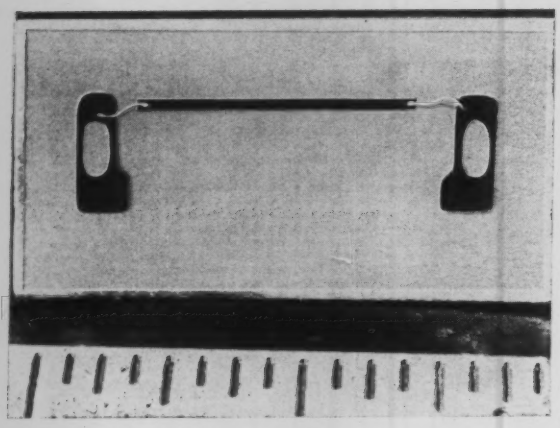


FIG. 15. WEKSLER Royal Gauge in case style AT for wall or direct mounting.

Weksler Instruments Corporation

Weksler's Royal Gauge (Fig. 15) is guaranteed accurate to 0.5% of scale range. Type 900RR has phosphor bronze bourdon, silver brazed to forged brass socket. Type 915RR has Type 316 stainless steel bourdon, welded to Type 316 stainless steel forged socket. Type 918RR uses beryllium copper bourdon, silver brazed to forged brass socket. Type 919RR uses K-Monel bourdon, welded to forged monel socket. Bourdon and socket are stress relieved after fabrication. Operation is by Monel and Inconel bushed rotary movement. Pointer has micrometer adjustment. Dial sizes are 3½″, 4½″, 6″ and 8½″, for stem or panelboard mounting. Black enameled cast aluminum case with threaded aluminum ring is standard. Cases also can be phenol, iron, or brass. Ranges to 10,000 psig are available.

Precision test gauges can be manufactured to order to an accuracy of ± 0.2%.



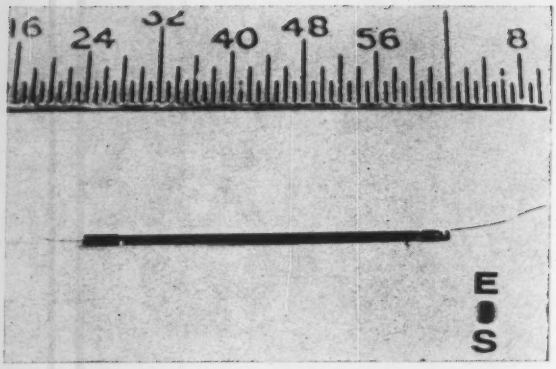


FIG. 1. SEMICONDUCTOR strain-gage filament on standard 1" mount (left). Filament is single crystal of rectangular cross section (right).

Semiconductor Strain Gage

Strain gages made from semiconductor materials can have gage factors up to 175, compared to 2 to 5 for metal-wire strain gages.

J. C. SANCHEZ
Micro Systems Inc.

SEMICONDUCTOR or solid-state strain gage (Fig. 1) uses the same principle as the metal (wire) strain gage—change in resistance with applied stress. Scientists at Bell Telephone Laboratories and the Case Institute of Technology several years ago [1, 2, 3] noted that when a semiconductor crystal is subjected to tension or compression, it undergoes a sharp change in resistance. In 1953 the piezoresistive coefficients of germanium and silicon were determined and found to be high. Gage factors were reported up to 175, as compared to 2 to 5 for metal wires.

The variables influencing performance include geometry, type and resistivity (doping) of material, crystallographic orientation, and type and methods of attachment of lead wires. A 2-year characterization program has determined optimum geometry, materials, and fabrication methods.[4]

TERMINOLOGY

Gage Factor: Percent change in resistance ($\Delta R/R$) per unit change in length ($\Delta L/L$)

$$G.F. = (\Delta R/R)/(\Delta L/L)$$

Strain: Unit change in length ($\Delta L/L$) of a material under stress. Magnitude is usually expressed in microinches per inch, referred to as "microstrain."

Stress: Applied force per unit area, F/A.

Physical Description

The Micro-Sensor* consists of a thin, flexible rectangular filament (Fig. 1) of a single-crystal silicon (type p 111) mounted on an epoxy-base carrier for application. The silicon filament is 0.020" wide x 0.0005" thick by approximately 5/8" long, with an active gage length of 1/2" (shorter lengths also are available). The carrier is a low-temperature-curing epoxy-resin and glass-cloth laminate with integral printed-circuit terminals. The gage can be installed around diameters of 1" or less without fracture of the silicon filament (Fig. 2). The unbonded filament can be curved around diameters of 1/4" without failure.

Model MS 105-350 has a resistance of 350 ohms; units with the same geometry can be produced with resistances of from 20 ohms to several megohms if necessary. (Present plans are to market gages with resistances of 120, 240, 350, 500, and 1000 ohms.) The temperature range of the MS 105-350 is approximately −65°F to +180°F. The

*Trade Mark

individual strain filament (model MS 115-350) is capable of temperatures in excess of 600°F; such filaments can be used with high-temperature cements for special applications.

Strain Sensitivity

The strain sensitivity (or gage factor) is defined as the unit resistance change ($\Delta R/R$) caused by an axial strain ($\Delta L/L$). Unfortunately this resistance change is not entirely linear with strain, especially in compression. Fig. 3, A shows a plot of unit resistance change ($\Delta R/R$) versus strain (plotted from -6000 to $+6000$ microstrain). The specific operating strain range of the Micro-Sensor is ± 3000 microstrain. The relative resistance change to applied strain is linear to within $\pm$½% between -500 and $+$ 500 microstrain (Fig. 3,B).

Temperature Effects

The filaments are stable (zero drift and creep) and free from hysteresis up to 500°F due to their single-crystalline nature. When bonded to a good heat sink the gage is capable of dissipating in excess of 1 watt of power at room temperature without failure or burn out; however, the effect of the induced self heating is rather drastic on stability, resistance change, and sensitivity. Best stability is obtained with power dissipations per gage of less than 0.10 to 0.15 watt. This is equivalent to gage currents of about 35 milliamps and 20 milliamps respectively for 120-ohm and 350-ohm gages.

An increase in temperature causes two undesirable properties—(1) a relatively high zero shift, and (2) a rapid change of relative gage factor. These effects can be minimized by special compensation techniques or circuit design.[5]

Circuitry

The Micro-Sensor normally is used with conventional strain indicating circuits and equipment for the measurement of small strains (0.1 to 500 microstrain). If higher strain excursions are expected, the bridge output will be sufficiently large to allow measurements using galvanometers, millivoltmeters and, perhaps, voltmeters or sensitive ohmmeters.

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4. E. D. Padgett, Picatinny Arsenal, Dover, New Jersey and W. V. Wright, Electro-Optical Systems, Inc., Pasadena, California, "Silicon Piezoresistive Devices," Instrument Society of America, Conference September 26-30, 1960, preprint number NY60-42.
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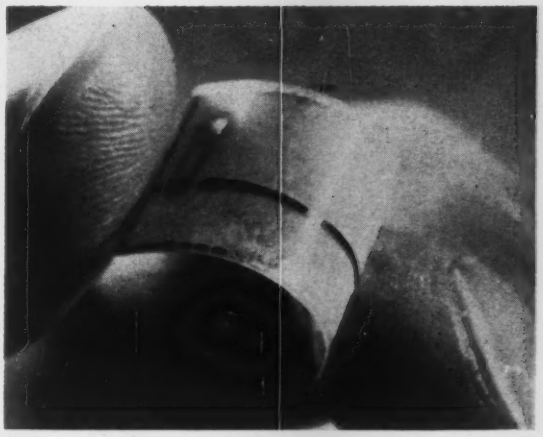

FIG. 2. GAGE bent to show flexibility.

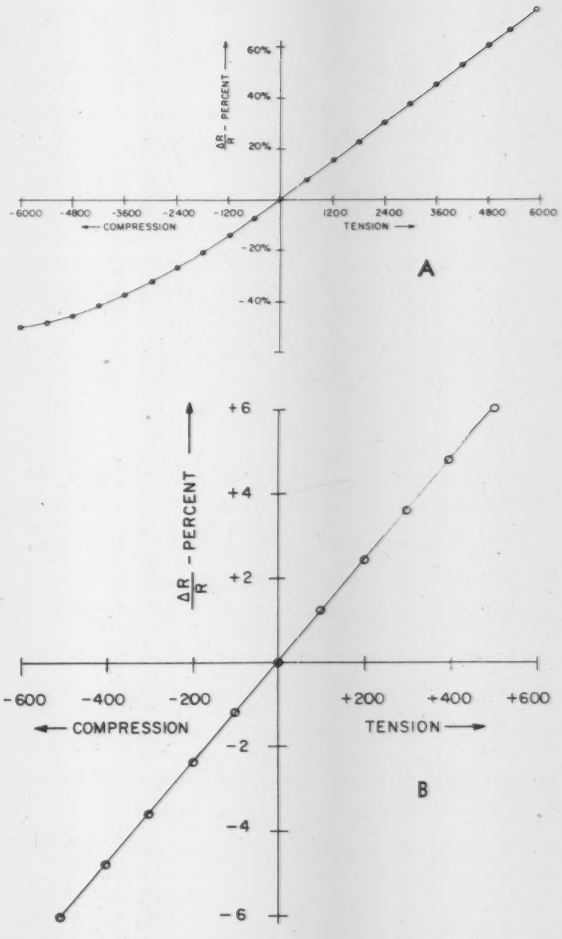

FIG. 3. STRAIN SENSITIVITY ($\Delta R/R$ vs strain in microinches/inch) of MS 105-350 bonded to aluminum with Eastman 910 cement and tested in constant-moment fixture. Strain is plotted in units of microstrain (microinches/inch). A shows test to ± 6000 microstrain, B shows test to ± 500 microstrain.

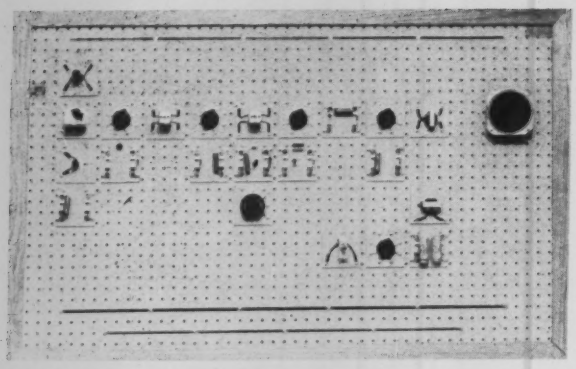

FIG. 1. DUMVILLE electronics educator.

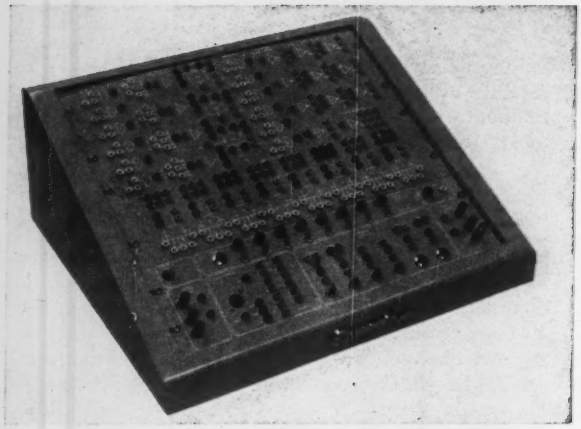

FIG. 2. EPSCO logic trainer.

Education Aids

Aids include (1) plaque-mounted components and panelboard for quick assembly and demonstration of electronic circuits, (2) computer logic demonstrator, (3) servo demonstrator, (4) symbolic-logic trainer, and (5) computer-controlled teaching system.

ELECTRONICS EDUCATOR of Dumville Instrument Co. (Fig. 1) uses a 30" x 48" board (for full class viewing), with all electronic components mounted on separate plaques.

The following outline is a tested teaching order suggested for use with the trainer.

Unit I, Basic Electronics.

Unit II, Intermediate Electronics, presents more advanced circuits.

Unit III, Advanced Transmission, produces transmitter with 500-mile range on phones.

Unit IV, Trouble Shooting.

Unit V, Instrumentation, produces popular instruments to give students a thorough concept of inner workings of test equipment—multimeter, signal generator, signal tracer, full oscilloscope.

Unit VI, Advanced Electronic Circuitry, includes various pulsing circuits, Geiger counter.

Unit VII, Automation and Control Circuitry, develops basic control circuits from simplest SPDT switch, through "thought" circuits of elementary nature, including radio control, relay control, photo control, servos, strain gage, sequence timer, plus a comprehensive introduction to computers.

Logic Trainer

Epsco, Inc., offers a Logic Training (Fig. 2) containing standard, off-the-shelf transistor digital circuit modules. It is a portable self-contained unit.

Forty pre-wired S100 digital circuits are connected to plug-in pin jacks. All connections are made on the patchboard panel with pin-jack jumpers. The front panel contains logic symbols for each circuit which clearly identify circuit functions and all input-output connections. Variable-frequency pulse sources, control switches, pushbuttons for manual operation of the circuits, and indicator lights for circuit displays are provided.

The Logic Trainer is available in two models, with or without internal power supply.

A pushbutton associated with the input to each flip-flop allows individual setting of each flip-flop for such demonstrations as pre-setting of a binary counter or establishing a "word" in a shift register. A pushbutton manually resets all flip-flops.

Although designed primarily for accelerating the educational process in basic digital circuitry, the trainer demonstrates effectively a large variety of advanced digital operations, such as full adder, a forward-backward binary counter, an eight-bit shift register, and taking the 9's complement of a number in a 1-2-4-8 binary-coded decimal counter.

Computer Logic Demonstrator

Burroughs Corporation offers a Computer Logic Demonstrator (Fig. 3), and has prepared a seven-week computer fundamentals course—a basic introduction to computer, data processing, and automation systems. A book entitled "Digital Computer Fundamentals" has been prepared. The demonstrator has horizontal panels for use by instructors to

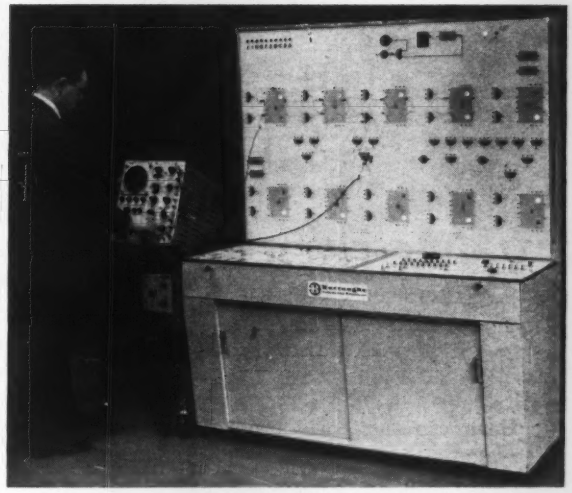

FIG. 3. BURROUGHS computer logic demonstrator.

set up initial conditions and to check out the aid. The vertical display panel duplicates the instructor's panel. The instructor explains basic concepts on the large unit. As the circuit gets more complicated he transfers wiring to his panel, connecting only those sections under discussion on the display panel and using a grease pencil to indicate other connections. The aid has two operating speeds, one for visual display and the other for scope display.

Dynamic Servo Demonstrator

Advanced Research Associates, Inc., has developed an ARA Dynamic Servo Demonstrator, Model 1 (Fig. 4) to demonstrate servo theory, design and application for use in schools. The demonstrator includes a high-performance velocity and position feedback servo system mounted on a 33" x 49" demonstration panel. The amplifier subsystem contains a single vacuum-tube preamplifier stage and a pair of matched (2N626 NPN and 2N676 PNP) 20,000-current-gain composite transistors as the push-pull drivers. This hybrid circuit eliminates multiple stages and ancillary circuitry in the amplifier to permit an easier understanding of the amplifier sub-system. Both vacuum-tube and transistor operation and system functions are demonstrated. The system is designed to permit the study and analysis of closed-loop and open-loop operation, transient response, transfer functions, etc., under load and no-load conditions. Both single-loop or multiloop feedback can be used.

The servo system's output actuator positions a simulated control surface in the outline missile's tail section. Schematic and functional diagrams are silk-screened on the panel and are large enough to permit easy observation from the back of an average-sized classroom. Each component is mounted close to its schematic symbol.

The instrument is supplied with a comprehensive, illustrated manual that covers basic operation of the demonstrator, and provides background information on servo system theory and operation.

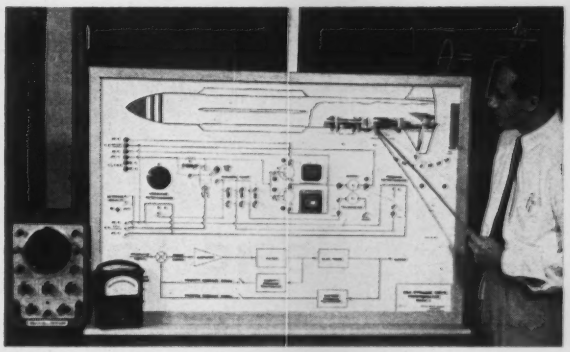

FIG. 4. ADVANCED Research Associates servo demonstrator.

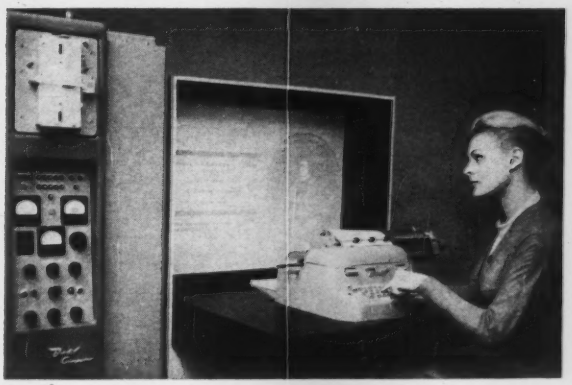

FIG. 5. SDC computer-operated teaching system uses Bendix G-15.

Automated Teaching

A computer-operated teaching system with the ability to tailor its instructions to an individual student's talent has been demonstrated by System Development Corp., Santa Monica, Calif.

Heart of the system is a Bendix G-15 electronic computer, which is programmed to sense a student's needs, respond to his errors, and build his knowledge and confidence quickly and reliably. When properly programmed the system could work with as many as 100 students simultaneously, but on an individual basis.

The automated teacher demonstrated a series of questions on Christopher Columbus. The multiple-choice questions were displayed by a slide projector called up by the G-15. The student answered by pressing a key on an electric typewriter. The computer immediately acknowledged the answer as "right" or "wrong," ordered up another slide, and began to keep a record of performance on each question.

When the student missed a question, the machine "detoured" him to a special set of remedial questions. Once his performance on the remedial set was satisfactory he was returned to the mainstream of the course, to be detoured again only when he was unsure of an answer.

Thus the machine can help both the bright and the slow learner. If the student's performance is high enough he can skip whole items in the basic series.

Basic Telemetry Methods

WILLIAM F. KAMSLER
Epsco-West

Here are the basic types of telemetry systems, including the popular pulse and frequency techniques. This begins a series on telemetering techniques, including a survey of available equipment.

A TELEMETERING SYSTEM is made up of the following elements:

1. **Sensing Element**—a device which will convert the variable to be measured into a suitable electric quantity.
2. **Multiplex-Modulation Equipment**—a sub-system which converts the electric output of the sensing element to the necessary form for application to the transmission system. Where sensing elements are handled by a single transmission link, the multiplexing system selects the signals for transmission.
3. **Transmission Equipment**—the components required to impress the telemetering intelligence upon the transmission medium.
4. **Receiving Equipment**—the element which extracts the signal from the transmission medium and prepares it for decoding and demultiplexing.
5. **Decoding-Demultiplexing Equipment**—the sub-system which recovers the original electrical quantity from the form used in transmission and identifies the source.
6. **Presentation Equipment**—the recording or control elements which receive the data.

In all telemetering systems, consideration must be given to the following design factors: (1) Accuracy, (2) Response Time, (3) Sensitivity.

The accuracy of a system is a measure of its ability to reproduce the desired measurement. The response time depends on the bandwidth. The system sensitivity is generally limited by the signal-to-noise ratio of the sensing element although, in many cases, it depends on the performance of the transmission channel.

Abstracts from a paper delivered at the National Telemetering Conference, May, 1960, Santa Monica, Calif.

Types of Telemetry Systems

An electric telemetering system may transmit the desired intelligence as any of the following variables:

Current
Voltage
Pulse Coding
Time Interval
Frequency
Position or Phase

Earliest telemetry systems transmitted voltage, current, or coded impulses over a pair of interconnecting wire lines.

In crude indicators, the quantity to be measured varied the resistance of an electrical circuit; an ammeter at the receiving location then could be calibrated in terms of the telemetering quantity. Accuracy is adversely affected in this system by variations in supply voltage and by resistance change in the interconnecting lines. To overcome these inaccuracies, the techniques of *current or voltage balance* were applied.

In *current-balance* (Fig. 1), a current proportional to a measured magnitude creates a magnetic force. This is opposed (at the transmitter) by a

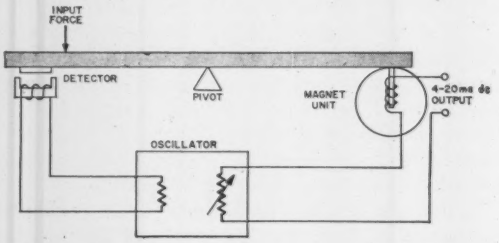

FIG. 1. CURRENT telemetry uses force-balance technique.

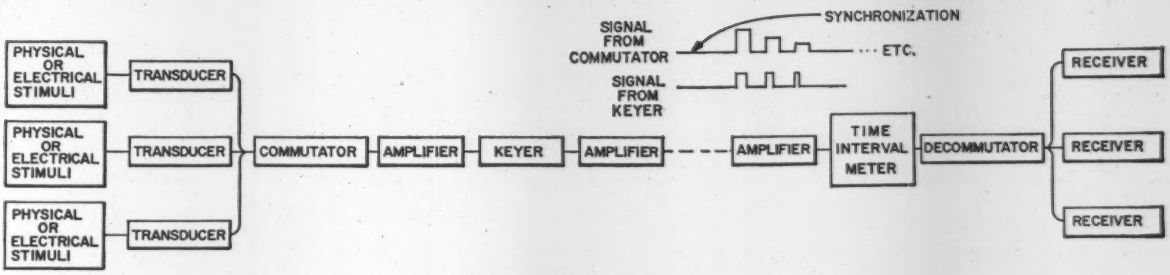

FIG. 2. PDM telemetry.

force derived from an automatically adjusted current developed at the receiving end. Variations in resistance of the connecting lines do not affect the results in this system because the current developed at the receiver is automatically adjusted to balance that of the measured magnitude at the transmitter.

Voltage-balance systems operate in a similar manner, except that the voltage balance is made at the receiving end, and only during variations of the measured quantity is there any current flowing in the lines. In the absence of "leakage" (shunt conductance) in the lines, the bucking voltage will equal the transmitted voltage within the sensitivity of the balancing system. The widely-used null-balance recorders are of this nature.

The systems just mentioned use a single sensing element connected by wire to a single piece of receiving equipment. The next advance was the use of a single receiving unit with many sensing elements, commutated one at a time to the receiver.

Pulse Techniques

Pulse Amplitude Modulation

The transmitted signal can be a series of pulses whose intelligence is conveyed in the *amplitude*. This is PAM (Pulse Amplitude Modulation). This system is widely used to increase the capacity of an existing telemeter for slowly-changing data. It also forms the basis for the transmission of television pictures.

Other pulse-type telemetry systems are based on *time*. That is, the intelligence to be transmitted is a function of time. These have several forms such as impulse-counting, impulse-spacing or pulse-position modulation (PPM), impulse-duration or pulse-duration modulation (PDM), and impulse-coding or pulse-code modulation (PCM).

Pulse Counting Systems

Pulses can be developed in a transmitting unit in which each pulse represents a definite increment of the measured quantity. This principle has found considerable application in water-level indication. "UP" pulses are distinguished from "DOWN" pulses either by polarity in a two-conductor circuit, or by the selection of wires in a three-conductor system.

Such systems are not "self restoring" because the signals for impulses are increments rather than absolute values of the measured quantity; either an auxiliary control or manual operation must effect resynchronization after an interruption in service.

Pulse-Spacing Systems (PPM)

Pulse spacing systems use two or more groups of signals. One set recurs at uniform intervals to establish definite time cycles. The other signal is delayed according to the magnitude of the measured variable. For example, the timing signals might occur at intervals of ten seconds. Each timing signal is followed after a period determined by the magnitude of the measurement by the signal representing the measured quantity. Again, for example, let this period be eight seconds. Should the measured quantity drop to half its former value, the measured-value signal would follow the timing signals by an interval of only four seconds. Any change in value measured by the transmitting instrument changes the spacing between the fixed and the variable pulses.

The pulse-spacing method appears to have originated in meteorological investigation, where it is required to transmit many signals over a single link that is subject to great and unpredictable attenuation.

Pulse-Duration Systems (PDM)

The best-known (and probably the most popular) method of telemetering by pulses is the pulse-duration method, in which the signal is on for a duration of time proportional to the magnitude of the telemetered signal (Fig. 2).

The chief advantage of the pulse-duration modulation is its ability to transmit a large number of channels of information over a single transmission link. Other advantages are the high accuracy (better than 1% over-all), made possible by self-calibrating features, and the inherently high signal-to-noise ratio resulting from the narrow signal-frequency bandwidths involved.

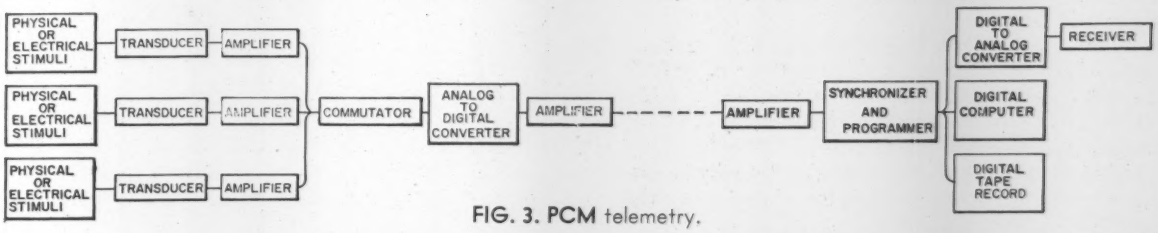

FIG. 3. PCM telemetry.

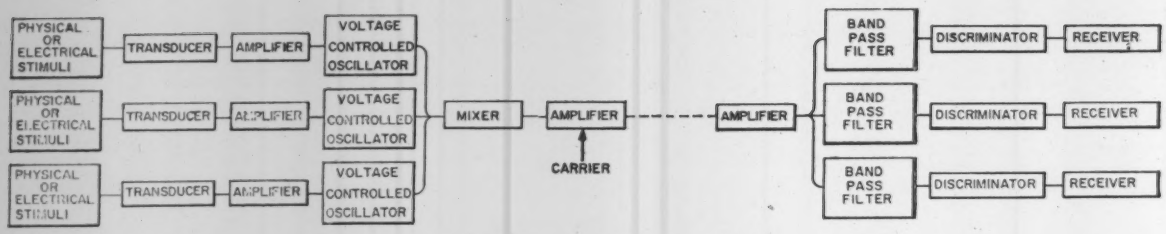

FIG. 4. FM/FM telemetry.

Pulse-duration modulation is applicable for a multiplicity of signal channels having relatively low-frequency content, such as thermocouples, strain gages, etc.

Pulse-Code Modulation (PCM)

In PCM, data are first converted into digital form and transmitted as a series of discrete pulses coded to indicate the magnitude of the variable. High-speed electronic analog-to-digital sampling and conversion equipment now permits commutating and transmission rates well in excess of 10,000 samples per second with accuracies of better than 0.01% of full-scale range. Fig. 3 shows PCM.

Pulse-code telemetry finds it main application with digital data loggers, computers for automatic control of an industrial process, and high-speed data acquisition systems.

Frequency Telemetry Techniques

Tone Telemetry

The earliest frequency telemetry systems used several oscillators that could be switched onto the transmission line. Such tone telemetry systems are still popular; many tones can be simultaneously transmitted over the same line at the same time. At the receiving end the composite signal is applied to a group of bandpass filters, one tuned to the tone of each oscillator. Each filter is followed by an amplifier, tone detector and a sensitive relay. Thus, at the receiver, a particular relay closes in response to the transmission of a particular tone. Tone telemetry systems have found their primary industrial use in on-off type remote control and annunciator use.

Frequency Modulation (FM and FM/FM)

In frequency-modulation telemetry systems, the input signal is used to vary the frequency of a voltage-controlled oscillator around its center frequency (a particular frequency corresponding to a zero input signal). An a-c input signal will deviate the carrier alternately on both sides of the center frequency.

Eighteen standard frequency bands have been set up, permitting frequency deviations of ±7.5%. The last five bands also can be used with ±15% deviations to obtain higher bandwidth, by omitting certain intermediate bands.

Data is read at the receiving station by a *frequency discriminator*. Attenuation variations in the transmission medium which seriously degrade amplitude data have no effect upon frequencies once a minimum signal-to-noise ratio is achieved. Wired-wireless (or carrier current), radio, and microwave links use FM. Multiplexing is simple; all 18 bands can be transmitted simultaneously over the same telemeter link. Composite transmission of several FM signals simultaneously is known as FM/FM (Fig. 4).

The waveform of the transmitted signal, from d-c to the bandwidth of the channel, is accurately preserved. Transient data having rise times as short as 125 microseconds can be resolved. This method of telemetry readily lends itself to magnetic-tape recording where, upon playback, the frequency components of a given signal can be scaled up or down by factors up to 1,000 or more.

Synchro Position

The simplest forms of *position* telemetering systems have used electromechanical voltage dividers at the transmitting end to control the ratio of voltage or current handled by two circuits. These circuits, which may have a conductor in common, are read out by use of a ratiometer, such as the crossed-coil type.

The position motor or synchro (better known by various trade names such as "Selsyn" and "Autosyn") is one of the most widely used position systems. Its greatest application is in relatively short links. In its basic form the system utilizes identical units for transmitting and receiving. These are structurally a-c synchronous machines having polyphase stators and single-phase rotors. With the rotors excited from a common a-c source and the polyphase stator windings properly interconnected, the rotors of the two machines will assume corresponding positions. In a plant where a-c power of a common phase is distributed throughout, only three conductors are required to transmit this type of position indication (Fig. 5).

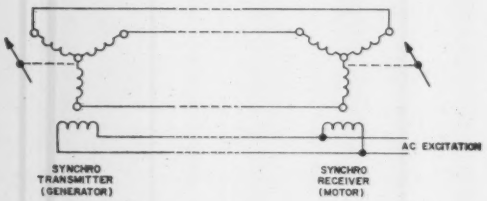

FIG. 5. POSITION or phase telemetry via synchro.

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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Telemetric Control and Communication

GEORGE A. HANINGER
Southern California Gas Company

What does it cost to telemeter information? What does it cost to include control functions? What are the annual leased line costs? What are the equipment costs, possibilities of expansion, growth of the system, flexibility of the system and other factors influencing the design of telemetric control?

USE OF TELEMETERING and remote control is increasing in industry because it provides a more efficient and economical method of operation. As industrial systems become more complicated, additional information and more local and remote control will be needed by those who operate the system. Telemetering and control can supply that need, giving the operator a picture of the system, and a means of changing that picture if necessary.

Telemetering is the transmission of information from a remote location, where the measurements are made, to a local point where the measurements are transferred into useful information.

Control is the changing of the position of some remote equipment or quantity such as a valve, controller, flow rate, or pressure set-point. Before telemetric control a man had to drive out to the remote station to make a change, or make a phone call to a remote operator to tell him to do something. Today, most control still is done over telephone lines, asking an operator to change the position of equipment or to perform a certain operation.

To achieve telemetric control, a pushbutton can replace the local telephone, and a relay can replace the telephone at the remote station. The operator at the local station sends a signal or code over the telephone line simply by pushing a button. This signal, received in a fraction of the time it would take to transmit the same message verbally, performs a specific operation, leaving the operator at the remote station free to attend to his other duties without interruption.

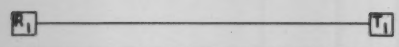
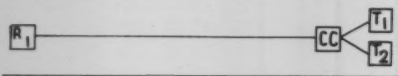
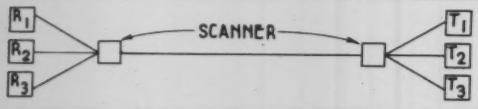
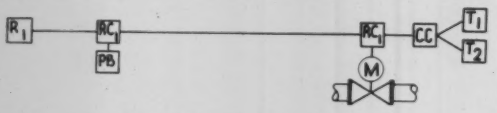
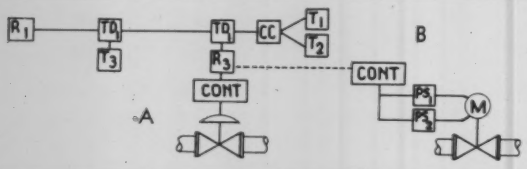
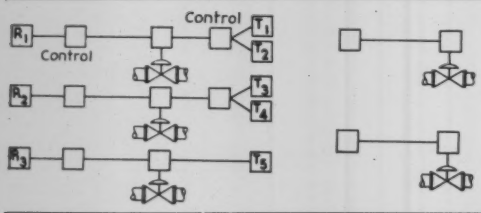
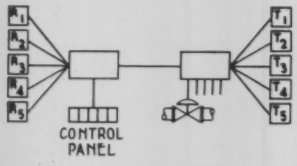
Why telemeter information? Why not have the man located at the remote end give the operator the information required by telephone? By telemetering, the local dispatcher can receive information continuously and need not interfere with the duties of the man at the remote station. If the man at the remote station happened to be some distance from the phone, he and the dispatcher would lose time. With telemetric information, the system can be operated more efficiently, operating expenses are reduced, and the system information is available as it is needed.

Meeting Notice—Thursday, July 20, 1961, Rio Hondo Country Club, 10627 S. Old River Road, Downey, Calif.
Dinner—6:30 p.m.; Meeting—8:00 p.m.
Subject—Viscosity Measurement and Control.
Speaker—Mr. K. E. Hallikainen, President of Hallikainen Instruments.

Cost Factors

How much does it cost to telemeter one item of information from a remote station? After it is installed, what are the operating costs?

Let us first consider a direct-current type of telemetering with a transmitter at the remote end and a receiver at the local end (Fig. 1).

	LEASE LINE COST $	ANNUAL OPERATING COST $	TOTAL $	
	540	280	820	**FIG. 1. TWO-LINE** system.
	540	435	975	**FIG. 2. TWO-LINE** system with two transmitters.
	540	1500	2040	**FIG. 3. SCANNING** several transmitters.
	540	735	1275	**FIG. 4. ADDING** one control function to system.
	540	1000	1540	**FIG. 5. REMOTE CONTROL** via electric-pneumatic unit (A) or pressure switches (B).
	2700	3000	5700	**FIG. 6. USE** of many leased lines raises line costs.
	(FREQUENCY SYSTEMS) 2000	3250	5250	**FIG. 7. FREQUENCY** system requires only one line.
	(D.C. PULSE CODE SYSTEM) 540	3250	3790	**FIG. 8. PULSE-CODE** system requires only one line.

The **transmitter cost** is approximately $250.00; the **receiver** about $250.00.

Now what about the cost of transmitting this information from one point to another? The **communication channel** is the tie between the transmitter and receiver. This channel could be a radio link, microwave link, a private wire, or a leased wire line. Let's assume a leased wire line because the installation of a wire line involves considerable capital investment; it is more practical to lease a wire line since the telephone company or wire leasing agency is in this business and can effect economies in multiple use of lines.

What is the cost of a channel when made up of a leased line wire?

The cost of a leased wire is based on a *miles-per-month basis*. If two stations are 30 miles apart, the rental cost for one month would be $22.50, assuming 75c per mile per month (single line and ground return).

This one line and ground return can be used only if the voltage drop is kept down to a point where the equipment will function properly. If the line resistance is too high and the voltage has been set to its maximum (as allowed by the company from whom the wire has been leased), it then will be necessary to lease a pair of wire lines, instead of the single line and a ground return. These two lines then will cost about $1.50 per mile per month, or $45.00 per month total rental for the communication channel (30 miles).

Figs. 1 to 8 show the cost of a leased line plus the annual operating cost, which includes depreciation of equipment, maintenance of equipment, interest on money borrowed to purchase and install the equipment. In total, 25% of material and installation cost was used for annual operating cost in comparing the different telemetric systems. (Note: cost of the telemetering equipment is not shown in Figs. 1-8.) For example, Fig. 1 shows a two-line system, costing $45 per month ($540 per year) plus $280 annual operating cost.

TABLE I—EQUIPMENT, INSTALLATION AND ANNUAL OPERATING COST* FOR VARIOUS SYSTEMS

Fig. No.	Equipment Cost	Installation Cost	Annual Operating Cost
1	$ 560	$ 560	$ 280
2	900	840	435
3	3,000	3,000	1,500
4	1,430	1,510	735
5 a-b	2,000	2,000	1,000
6	5,600	6,400	3,000
7	9,800	3,200	3,250
8	9,800	3,200	3,250

* 25% of sum of Equipment Cost plus Installation Cost.

Transmitting More Information Over One Channel

If a telemetering circuit has been installed at a lease-line cost of $45.00 per month, this communication channel should be used to the utmost. What can be done to accomplish maximum use of this channel? If it is not necessary to have some item of information transmitted continuously, another item of information could be transmitted alternately, as shown in Fig. 2.

Here we have two transmitters tied to the same wire line. The 15-minute cycle of the cycle controller (CC) provides a means of first transmitting T1, then T2, at regular intervals. Both transmitted signals would be received by the one receiver at the local station; the interpretation of which signal, T1 or T2, was being received would be determined by the length of time the signal is recorded. For example: one transmitter could transmit for 12 minutes, while the other transmitter could transmit for 3 minutes in a 15-minute cycle. The long 12-minute recording of the signal would identify T1, the shorter 3-minute signal would be T2. The cycle controller can be adjustable so that the times of 12 and 3 minutes could be changed.

The capital costs now are $500 for the transmitters, and $60 for the cycle timer at the remote end, and still $250 at the receiving end. The line rental cost is still $45 per month, assuming a two-wire line and 30-mile station separation. This cycling or multiplexing of transmitted signals can be increased to number more than the two mentioned. There is equipment manufactured which will go as high as 15 points of telemetering; however, if over 3 points of information are telemetered, some type of synchronizing equipment is required to assure the opperator of receiving the correct transmitted information on the correct receiver.

Fig. 3 shows the components required to cycle 3 or more items of information. The cost for 15 points of scanning would be about $750 for the remote end, and $750 for the local end. The synchronizing equipment can be built into the scanning or multiplexing equipment, or other methods of synchronizing could be designed into the equipment where necessary. In designing multiplexing systems, where the telemetric points of information number more than 3 and the elapsed time of receiving a measurement and receiving that measurement is critical, consideration should be given to the total scanning time of the multiplex equipment.

In pulse-time-duration telemetering with 5-second cycling of the transmitter instrument of 15 scanning points, the total scanning time is approximately 3¼ minutes. This may be too long a time for the operator to be without knowledge of what is going on at the remote station. This over-all scanning time could be reduced by repeating the telemetered variable so as to cut the elapsed time between the reception of the same items of information. (This would be to transmit the information more often.) Another method would be by the use of a digital-type transmitter, or by the use of frequencies to transmit the various telemetered signals. As the frequency system would not entail the use of scanning-type equipment, no synchronizing signal would be needed; all frequency-type telemetered signals could be received simultaneously. In each of the two systems mentioned, one receiver would be needed for each transmitted signal. In addition, the frequency system would require a lease line of the type which would transmit frequencies with minimum loss.

Adding Control to Existing Leased Lines

Now that information is being transmitted from the remote station, it might be advantageous to control the system at the remote end. This change could be the starting or stopping of a valve, changing the position of a valve, changing the set point of a controller, etc. Fig. 4 shows an addition of a control function to the telemetering installation of two variables being cycled.

This control is a device (RC_1) located at the local and remote stations. By means of a push-button at the dispatch station, the valve at the remote station is operated. Motor M is opened or closed as required by the dispatcher. The control device shown in Fig. 4 can, in addition, perform functions such as stopping the valve at any position, or send back indications on when the valve is fully opened or fully closed. (This is referred to as a block-valve controller in our Company.)

This block-valve control unit can also be used to position a valve because of the stop circuit designed into the control. For example: if the operator should start opening a valve at a remote station, he may stop the opening process and the valve will remain in the stopped position. At this point he may complete the opening process or close the valve, as needed. The valve opening or closing time also can be independently controlled. The valve opening can also be set to open slow and close fast, by means of a preset pulsing timer at the remote station.

The *position* of the valve is transmitted back to the dispatcher to indicate, by means of lights, the open or close position. Limit switches, located on the valve, indicate the check back or position signal of the valve. In some installations it is advis-

able to advance the position of the valve fast for the first segment of its travel, and then the remaining travel of the valve must be slow. This is done with a third limit switch which by-passes the pulsing timer for this segment of the valve travel. All of the operations are performed with D-C (direct-current) voltage only, and polarity reversal. Security also is built into the circuit to prevent any false signals from initiating an operation. If the valve at the remote station is changed manually, a valve position signal is sent back to the local station to indicate a change in valve position.

When a control function is performed, telemetering is switched out of the circuit until the control signal has completed its operation, after which the telemetering returns to normal. The cost of such a control function is about $500. Now the system consists of a telemetering and control system, which will cost $1,470.00.

Using this same set up with telemetering and control, but using an *electric-pneumatic control* at the remote station, would result in the system shown in Fig. 5a.

Here the remote control, (RC 1 in Fig. 4) has been replaced with TD_1. These units are called *transfer devices;* they transfer the communication channel from telemetering to control. In the transferred position, the operator can, by means of a transmitter (T_3), send a signal similar to T_1 and T_2 to the remote station. This T_3 signal is received by receiver (R_3) at the remote station. The receiver (R_3) is mechanically tied to the controller which changes the set point of the controller. Because of this change of set-point, the output of the controller is changed, which in turn causes the valve to change its position. If the valve is pneumatically operated, the output is fed directly to the diaphragm head of the valve. If the valve is electric, then the pneumatic output if fed to two pressure switches PS_1 and PS_2 (see Fig. 5b). These pressure switches are set as follows: PS_1 is set to close its contacts if the control pressure from the controller is 3 psi or less; PS_2 is set to close its contacts if the pressure from the controller is 12 psi or more. The closing of the pressure switches energizes the motor through its motor control equipment, to open or close the valve.

Controlling by this system is more expensive because of the controller and additional transmitters (T_3) and receiver (R_3) used to transmit and receive the signal. The system in Figs. 5a and 5b is incorporated in control schemes where constant regulation of the variable is desired.

Now the system has progressed from a simple telemetering system to the more complicated system of control and telemetering. The cost of the leased wire line has remained the same—$45 per month.

Other Systems of Transmitting Information

Let us go beyond the point of telemetering two functions and adding one control function on the same leased wire—let us consider a system where 5 telemetering and 5 control functions might be required. Consideration must be given to a different system of transmitting the information and control signal.

Five telemetering and five control functions can be accomplished, but it will require five leased lines (Fig. 6). Since five leased lines at $45 per month would total $225 (based on 30 miles between stations), it might be well to consider some other method of telemetering such as the use of digital, frequency, or pulse code. With these systems, only one line would be required, at $45 per month (see Figs. 7 and 8). If a frequency-type code is used, the line cost would be about twice as much or more as the D-C type line. Equipment and instrument cost for 5 telemetering and 5 control functions would be $13,000.

Leased Line Rentals

At this point, let us look again at the rental of leased communication lines. The rental for wire lines for the systems previously mentioned was $45 per month. This was based on $1.50 per mile per month for stations separated by 30 miles. These costs are figured on straight line-of-sight mileage and not on the distance the wire line actually travels in getting from the local station to the remote station. The more information and the faster the information needs to be transmitted over the leased line, the better the quality of line needed and, consequently, the higher the line cost. If the pulses in digital or pulse code were to be at a rate of 15 cycles per second (cps) or less, then the lease rate would be as mentioned above. If the pulse rate is higher than 15 cps, then the lease rate would be higher. Most manufacturers design their equipment for use on lines where these restrictions would be imposed.

Equipment using audio frequencies over leased lines have a frequency range to 2750 cycles per second. In using these frequencies, the quality of the line must be higher than that of the 15-cps type, thus its cost would be higher. The line cost, when using audio frequencies, range from $3.00 to $7.50 per mile per month, depending on the leasing area. Thus it can be seen that if signals made up of frequencies were used in the telemetering and control functions, the 30-mile leased line cost would range from $90 to $225 per month. This higher cost might be justified, for example, where more telemetering and control functions are wanted, where more security is desired in the system, where the rapidity with which the dispatcher needs the information is important, etc.

Line Characteristics

The characteristics of the equipment to be used on leased lines is needed by the company from whom the line is leased. It is equally important that the company leasing the line determine the characteristics of the line being leased. If direct-current or pulse-type equipment is to be used, the *resistance of the line* is important and should

be known. If control is in two directions, it will be necessary to know if *repeaters* are installed in the leased lines. If repeaters are installed in the line, it would be essential that they be two-way repeaters because signals will be sent in both directions. In addition, the decibel loss of the line where audio frequency is used will need to be known, together with signal-to-noise ratio.

The following example shows where line characteristic information is important, together with the delays that might occur: A request was made for a lease wire, with circuit resistance of 2000 ohms. Unfortunately, the ground conditions in the remote area of installation were such that a ground resistance of 6000 ohms is encountered without adding in the wire resistance of the circuit or the equipment resistance. Hence one wire and ground return couldn't be used. The problem was solved, temporarily, by using two metallic wires, paralleling them, and using the pipeline as a ground return.

One telemetric installation of this type would be enough to assure anyone of the wisdom of checking continually with the line leasing agency or power company in order to be certain that the leased facilities complied with the specifications required. The installation of power and communication lines does not give assurance that the job will work. Other factors can delay the job, such as the various leasing agencies not being able to comply with needed requirements, wrong assumptions used in their design, misunderstandings, etc. It is not unusual to have the power company or leasing agency present you with a different method of meeting your specifications, at additional cost.

The fact that the leasing agency changed their line design to meet required specifications does not always solve the problem. Their changes may mean additional changes to the equipment and, depending on these modifications, the over-all equipment design should then be reviewed to see if any other part has been affected. Here is where flexibility in design becomes important. If the design is flexible, all changes needed for either the leasing agency or the company requesting service can be made.

The use of frequencies includes many of the same problems. It should not be assumed that leasing a high-quality line for use with audio tones will allow low-grade signals to be superimposed without difficulty. The line may not be a continuous metallic line from remote station to local station as requested, and audio amplifiers may have been inserted to minimize the line loss. Also, the insertion of an audio amplifier (or repeater) would prevent the use of polarity reversal operation or the use of direct-current check back.

Lead Time and Specification Assurance

The amount of time required by serving agencies to complete their work in order to meet required specifications will depend on the size and complexity of the job, the location of the job, and whether the serving agencies are local or not. If

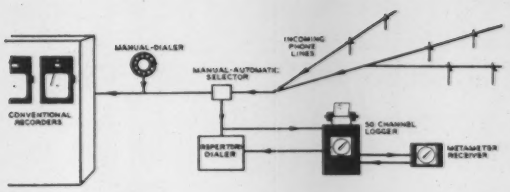


FIG. 9. FLEXIBILITY permits logger to be added to system. (Photo courtesy The Bristol Co.)

the communication channel for the job extends into leasing agencies of two or more areas, the problem is more complicated. One agency may have facilities, the other may not; one agency may understand your problem, the other may not. Sufficient time to construct their facilities to the remote station must be allowed; in some desert areas, this can mean months of construction time. In addition to this construction time, there is an item of cost—construction line costs which may have to be paid. If this is considerable, it may be better to relocate or change the location of the station itself, or at least the telemetering and control facilities. The same is true with regards to obtaining power from power companies.

The cost to build in communication facilities also depends on many factors. The facilities may already be located near by, or the serving agency may feel that the revenue obtained from leasing their facilities will pay for extending their line. Also, there may not be construction costs as such, but a flat fee, for instance $2000 per mile. The figure could be higher or lower, depending on the conditions.

Flexibility in Design

The amount of flexibility which should be designed into a telemetric system is limited only by cost. Consideration should be given to flexibility throughout the design process so that the system can be changed in the future, as often happens. The system to be controlled may have to be enlarged or changed; the operators ideas may have changed; the designers ideas on how to do the job may change; the cost of the equipment to be included in the design may be more expensive than originally planned because of manufacturers equipment design or because problems caused the manufacturer to change his equipment; the communication channel characteristics asked for may not be met. The additional design time spent to achieve flexibility may be more, but in the long run it will be found that this will pay off.

Specific places where flexibility of design should be considered are (1) in the retransmission of telemetric information after it has been received at the dispatch station, (2) in the conversion of the signal from analog to digital, (3) the insertion of this information into computers, or (4) where the use of telemetric information performs control functions automatically. Consideration should be given to the fact that although continuous tele-

FIG. 10. GAS DISPATCH station uses telemetry. (Photo courtesy The Bristol Co.)

metering is essential for the dispatcher at present, it may be eliminated later. Where many items of information are transmitted at present, only one may be transmitted in the future and all measurable variables would be combined into one quantity. That one quantity would then be transmitted to the local station.

Compressor Plant Remote Control and Telemetering

The cost of remotely controlling one compressor plant and telemetering the information required by the dispatcher for the remote control equipment was about $25,000. This would allow the dispatcher to initiate the start of any of 10 compressors. Once initiated, the compressor would then complete its own starting and sequencing from its individual local controls. This price included approximately 30 points of telemetering.

The controls and telemetering would consist of three groups; the station functions in general, the individual equipment functions, and the equipment shut down function. In brief, in gas compressor plants, the station functions would consist of telemetering of pressures up and downstream of the station, gas fuel, starting air, etc. In addition, there would be certain control functions necessary such as operating valves and shutdown on the station, loading and unloading compressor pockets, and the necessary check back functions that inform the operator of other station conditions.

The individual compressor telemetering could consist of engine speed and engine oil pressure and other information necessary to the operator when the compressor is to be started or stopped as the case may be. When only start-stop control is provided, the compressor locally will go through its automatic sequence. The compressors not set up with an automatic local sequence panel will require other control functions.

The equipment shut-down functions consist of high water jacket temperature, overspeed, oil pressure, etc. The number of these functions, which help the operator know what has happened at the station, could run to as many as 10 per engine. With ten engines, this could amount to as much as $10,000 for sending back this information. To cut this cost, these functions could be grouped in groups of three. If the engine failed, then the operator would know the group in which the failure occurred, and from this can determine whether to start the engine again. This would reduce the cost for this check back information to about $3300.

In order to cut down on the number of telemetered points required, these points also could be grouped. If one group indicates trouble or abnormal operation, that particular group could be switched in automatically or manually and allowed to telemeter its functions either simultaneously, or the group could be scanned to determine the one in the group that is abnormal. In doing this, the number of telemetric points could be dropped to 10 telemetric functions if there were three groups consisting of ten telemetering functions each. The control functions would be increased by three, assuming the necessity of selecting three groups.

Emergency Power

Where loss of power could occur, emergency generators should be installed. The cost of such installation for a 5-kw unit would be about $2000. This includes the generator unit and automatic transfer device.

Where there is a chance of loss of power, the telemetric control equipment and the end equipment that is being controlled should be designed in such a manner that it will fail in the position desired. That is, the equipment being controlled should be made to fail open, closed, as is, or to a predetermined setting or position.

The time delay between the time power is lost, and full voltage condition, may be a matter of 15 seconds or so. If electronic equipment is being used, there will be a loss of output by this equipment because of the loss of voltage in the filaments in electronic tubes. In addition, if the electronic controller is controlling a pneumatic installation, this 15-second delay might allow the system to bleed down and close the valve. To solve this problem, a seal-in circuit could be installed in the pneumatic lines to block it from bleeding, and a time delay relay to keep this seal-in circuit from unsealing until the electronic equipment has stabilized its output.

In mountain-top installations, where power is not available, a continuous running generator could be installed, or the generator could be set to start upon a control signal from the dispatcher when he wishes to change control at the station. At a location two miles from power, the cost of the power installation would be $20,000. This includes only getting power to the station, in addition, there would be the cost of getting a leased line to the mountain top location.

Automating A Complex Pipe-Finishing Operation

Data handling requirements for a pipe-finishing line include measuring length and weight, calculating wall thickness, making go-no-go decisions with different limits for each pipe and each car load, and marking each pipe with heat number, length, weight per foot, and total weight, diameter, hydrostatic test pressure, and manufacturer's name. Here is an automatic system for all the above.

GEORGE FRIED*

ADRIAN PHILLIPS**

AN automated system has replaced manual methods of data gathering functions on finished pipe—measuring length, weighing, checking average wall thickness, counting, segregating, stencilling, tallying, steel stamping, and banding. It requires less space, is run by one part-time attendant, and can process twice as many pipes as four men did previously, while giving data unattainable previously.

The American Petroleum Institute code allows the pipe to be plus 6½% above the nominal weight per foot, or minus 3½% below the nominal weight per foot, but it does not allow a carload weight to vary more than plus or minus 1½% of the nominal weight of the total footage of pipe. Also the American Petroleum Institute code requires less than 5% of shortlength pipe to be loaded in any one car. The tally man's functions are not simple.

However, in one modern installation, the following is being done *automatically*:

A. The pipe is fed onto a data-gathering bridge (Fig. 1). Here the pipe length, and its count are determined by electrical means.

B. A computer accepts or rejects the pipe after it has determined whether average wall thickness is within limits acceptable to the API code. This is done by a special computer which divides the weight by the length of each pipe and then compares this value with that which is acceptable to the American Petroleum Institute.

C. It automatically stencils on the pipe its length in feet and inches, its weight in pounds, the pipe manufacturer's name, the pipe's diameter, the weight per foot, and the test pressure.

D. It segregates pipe into different groups according to their weight or length.

E. It steel-stamps the American Petroleum Institute symbol and other identification on the pipe.

F. It puts bands of different colored paint on the outside of each pipe for identification purposes.

G. It shuts itself down automatically when a preselected number or a preselected total length or total weight of pipe has been processed.

H. It automatically identifies the operator who switched the system on and records his number and the total count of pipe processed until this operator shuts off the system.

I. It also records the minute, hour, and date that each pipe was processed.

J. It records the count of each pipe, its length, its weight, its heat number, its grade, kind, mill order number, mill order code, and tabulating code.

K. It records all subtotals and indicates these in large illuminated digits—the length, weight, and count of each pipe, and their running subtotals.

L. It records this data in printed form with multiple copies, and is built so that any or all of the data can be recorded on punched tape, punched cards, or magnetic tape.

Operation

The weight of each pipe is determined by a load-cell weighing system and a null-balancing servo system (Figs. 1 and 2). The technique uses a thermally-compensated weigh bridge so designed that the ratio of live load to weigh-bridge load is high. In addition, shockless loading of the pipe onto the weigh bridge is obtained by means of a cam-actuated pneumatic system.

Mem-O-Tizer

Directly coupled to the length-measuring system and to the weighing system is an analog-to-digital converter (Mem-O-Tizer), which has a self-

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*George Fried was with Telechrome Manufacturing Corp. when this work was performed, with position of Vice President. He is now President of Tech-Man Enterprises, Inc.

**Adrian Phillips was consultant on this project. He is a registered Professional Engineer, N. Y.

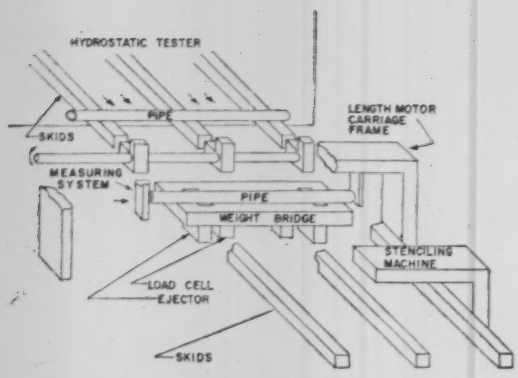


FIG. 1. PIPE FINISHING apparatus for measuring length, weight, etc.

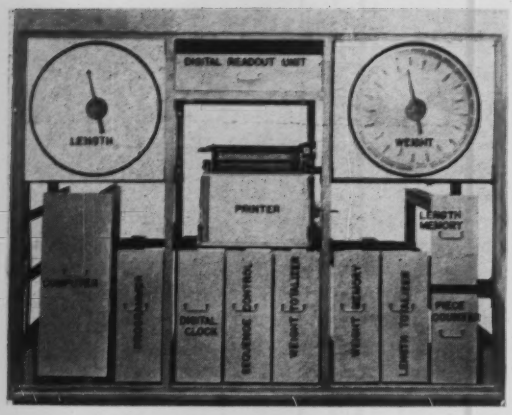


FIG. 2. CONTROL equipment console.

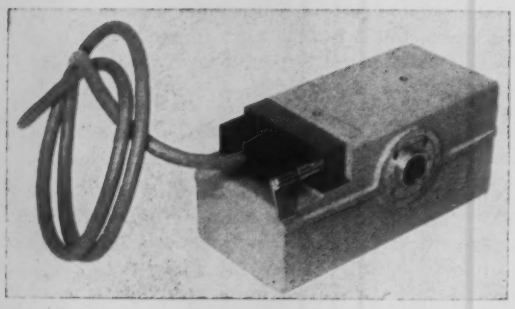


FIG. 3. MEM-O-TIZER analog-to-digital converter with memory.

FIG. 4. PERSONNEL IDENTIFIER.

FIG. 5. SPECIAL CHROMECTOR connector for industrial environments.

contained memory (Fig. 3). The memory has mechanically-locked contacts which correspond to disc patterns at time of code reading. These code positions can be transferred mechanically for independent operations of discs and switches. The input shaft is then free to follow the measured variable, except during the brief period of solenoid actuation. The readout time of this unit is 0.005 second. The readout rate is two per second continuous. The encoding rate is 20,000 counts per second. The output code contacts are rated at 1 amp at 60 volts dc.

Computer

The length and weight are fed into a special-purpose computer which accepts two digital decimal inputs X and Y and performs the arithmetic operation Y divided by X to obtain a quotient Q.

Automatic Stencilling

Decimal values of length and weight are fed into a diode matrix, converting it from decimal and duo-decimal into binary. This binary value triggers suitable magnetic amplifiers, which actuate solenoids causing a pneumatic servo system to set the stencils in their proper positions corresponding to the input data.

A continuously-traversing spray system then receives a signal to allow paint to flow through it. This paint is sprayed through the prepunched stencils, putting the proper data on each pipe. In the case of domestic pipes, the actual weight of the pipe and its coupling is stencilled. However, for export shipments a weight corresponding to that of the thread protectors (which will be added to the pipe later in the process) must be added. Pneumatic servos are then set to the higher or gross values.

Digital Visual Indicators (Video)

The video unit indicates individual length in feet and inches, weight in pounds, and their running subtotals. This is a modular plug-in display unit for digital information systems. This assembly consists of individual twelve-character display units. Cam-lock mounting hardware is included, which permits quick interchange of display units, without tools, for lamp replacement or lamp adjustment. Fig. 5 shows a special connector developed for industry.

Personnel Identifier

The operator is identified by a device which accepts and holds an inserted key (Fig. 4) and provides an electrically-coded output identifying the key which has been inserted. Upon insertion of the key, the subtotal of all the data in the system is recorded. This is done to give the operator whose key has been inserted a starting point from which the data will be charged against him.

Presented at Ninth Annual National Symposium on Industrial Electronics—AIEE/IRE September 21-22, 1960, Manger Hotel, Cleveland, Ohio.

INSTRUMENT MOTORS

Comments by Robert W. Matthews, Chief Engineer, Holtzer-Cabot:

"Reviewing all the problems, complaints and discussions which we have had with instrument engineers in the past ten years I believe that the Production and Design Engineers in the instrument field will be satisfied with a motor which will run for ten years without attention, have a response voltage of 1%, and a selling price of $5.

"There are two basic motor applications involved, the synchronous motor used for chart drive and the servo motor used for the pen drive. The chart drive motor is normally a continuously running motor while the servo motor may stay in null position a large percentage of the time. During the period the motor is at null, the rotor is oscillating or dithering continuously due to the fact that the reference winding is energized from the 60-cycle line and the control winding is supplied with a d-c from the instrument amplifier. This dithering causes fretting corrosion of bearings and gears due to the fact that the very small movement of the rotor squeezes out the lubricant from between parts and it is not replaced as would be the case in normal running conditions. Here we need a lubricant which will stay in place regardless of lack of film-building rotation.

"Both the chart and pen drive motors have a common requirement. These motors are normally placed in totally enclosed, non-ventilated cabinets along with other heat producing items so that the motor ambient is always 15 to 35 degrees C above room ambient. In many applications this means motor ambient is 60 C. Taking into consideration the temperature rise of the motor and the wide variety of installations, from furnace room to unattended automatic stations, we arrive at a lubricant temperature range of —40 C to 105 C. This top temperature may be increased as miniaturization continues. Insulation materials are available for higher temperatures.

"Another important requirement of the lubricant is shelf life. Due to lapse of time from manufacture of bearings to actual installation of recorder, shelf life must be a minimum of one year. While shelf life of one year is regarded as adequate for normal production, a much longer period is desirable to minimize inventory problems of both bearings and motors.

"Both chart drive and pen drive motors are normally used with several stages of gearing. Here again we need a lubricant with the staying qualities of glue, yet it must be smooth and quiet operating."

Comments by R. B. Walker of the New Departure Division of General Motors Corporation:

"In general, petroleum-base lubricants are most suitable over non-extremes of temperature, while synthetics, such as silicones, perform best at the extreme high and low temperatures . . . Generally, oiled bearings are noisier than greased bearings. Softer greases are quieter than stiff ones. Various other methods for reducing noise include preload springs, optimum internal clearance, coatings, ball size and quality."

Comments by E. H. Berg, Esso Standards Div., Humble Oil & Refining Co.:

"Regarding the use of a synthetic lubricant versus a petroleum based one, there is no general rule for selection. There are broad areas in which either will do a satisfactory job. However, petroleum lubricants are generally not suitable above 300F for extended periods of operation. Petroleum lubricants for extreme low temperatures are available but these are not suitable above 150F because of their high evaporation rate. Therefore synthetics have their greatest applicability where the operating temperature range is very wide or very high . . . Under boundary lubrication conditions, where a full fluid film does not exist, petroleum lubricants are generally better."

Comments by G. R. Arbocus of E. F. Houghton & Co:.

"Comparing the application of greases with oil, in general, grease is more practical for the following situations: (1) dirty or corrosive operating conditions where grease seals bearings against contamination, (2) inaccessible locations, (3) where spattering or dripping cannot be tolerated, (4) where running clearances are excessive due to wear or poor fit.

Oil is generally preferred for: (1) automatic lubrication, (2) certain high temperature operations where oil is misted and leaves a much lower residue than grease, (3) applications where relubrication is practical, (4) extremely high bearing speeds, (5) where cooling and flushings of bearings is necessary.

Comments by E. T. Johnson, Amplex Div., Chrysler Corp.:

"Powdered metal sleeve bearings are somewhat porous, and advantage of this feature is taken by filling the pores with oil. When oil can be supplied from a reservoir the density of the porous sleeve bearing is not critical; however, when a reservoir cannot be supplied, a low-density bearing, due to its greater oil capacity, is preferred. Vacuum impregnation maximizes the quantity of oil which can be retained."

Q. (*Johnson, Leeds & Northrup*) We have experienced start-up problems after equipment has been shut down for two weeks or more. Do you have any suggestions?

A. (*Berg*) If you do not need a wide temperature range, a petroleum based lubricant is your best solution.

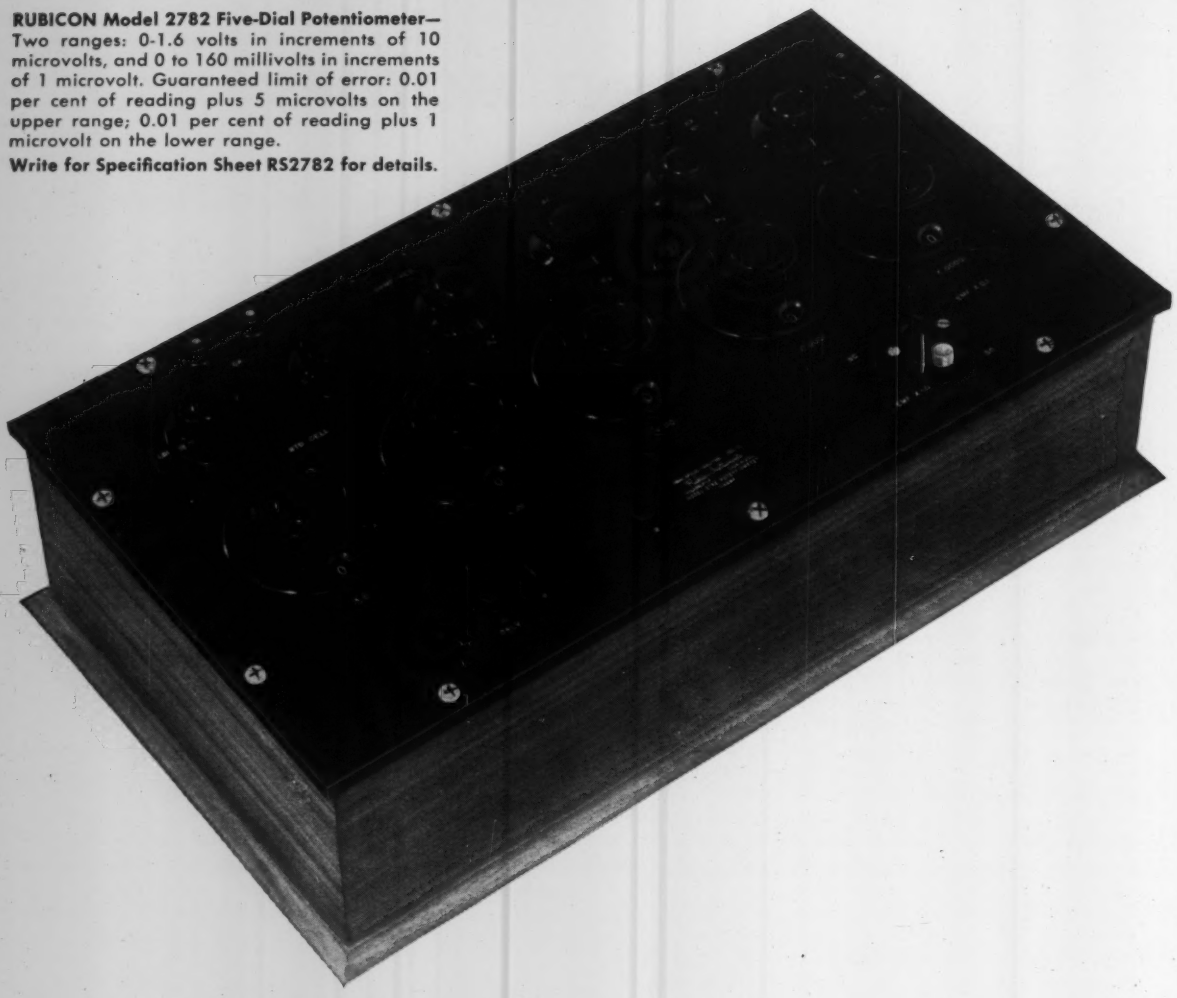
Q. (*John Garrigus, Bristol Company*) Which is better for dither applications, ball bearings or sleeve bearings?

A. (*Matthews, Holtzer-Cabot*) Seven years ago we would have answered sleeve bearings. Recent experience however indicates that ball bearings, properly applied, are the best.

Abstracts from The Third Annual Holtzer-Cabot Instrument Motor Symposium September 27, 1960, New York City, on "Lubrication of Instrument Motors"

RUBICON Model 2782 Five-Dial Potentiometer— Two ranges: 0-1.6 volts in increments of 10 microvolts, and 0 to 160 millivolts in increments of 1 microvolt. Guaranteed limit of error: 0.01 per cent of reading plus 5 microvolts on the upper range; 0.01 per cent of reading plus 1 microvolt on the lower range.

Write for Specification Sheet RS2782 for details.



HOW "ACCURATE" SHOULD A POTENTIOMETER BE?

Potentiometer accuracy claims can be misleading. They can sometimes be based on one-shot tests made under ideal laboratory conditions. Their validity can depend on the method used to establish limits of error.

The real measure of potentiometer accuracy is not how little the instrument drifts from set resistance values at one given moment, but how *long* it will remain faithful to its certified calibration. Only a potentiometer that gives consistently stable, reproducible results over its entire life can deliver the performance you pay for.

Such a potentiometer is the one shown above, our Model 2782. It incorporates refinements in potentiometer design that provide high stability and long-term accuracy. For example, the use of high-stability 10-ohm resistors in the first dial and 1-ohm resistors throughout the four lower dials insures permanence of calibration. And because the switch of the first dial carries no current at balance, its contact resistance can introduce no error of measurement. Many other design innovations help maintain the potentiometer's *realistically* high accuracy. Still, the instrument is priced below comparable potentiometers offering far less.

All Rubicon instruments are the product of a long tradition of engineering excellence and exceptional craftsmanship. The complete line is available through any of the Honeywell branches throughout the nation.

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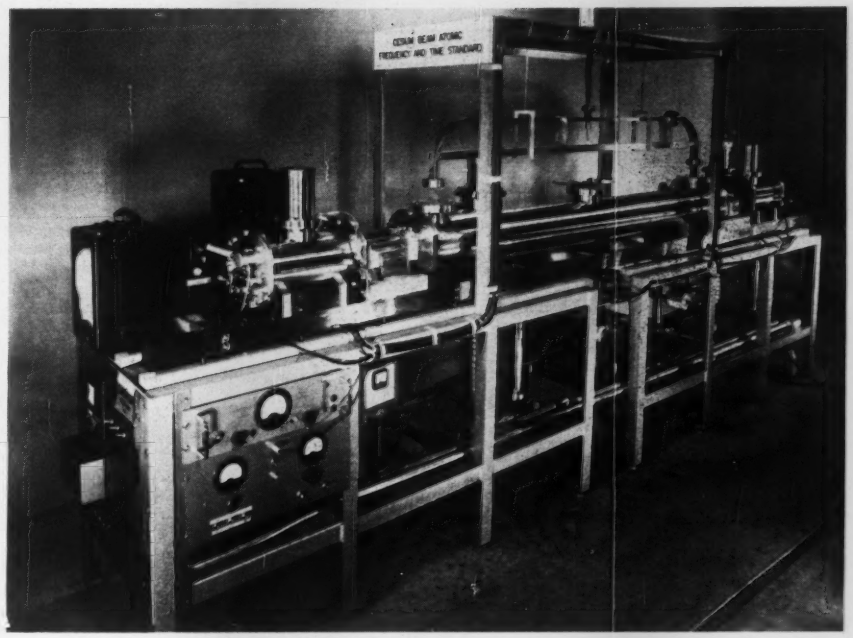


Fig. 1. **NBS-11** atomic-beam frequency standard. Spectral line width is 90-140 cps.

Atomic and Molecular Frequency Standards

UNTIL the development of atomic frequency standards, the most uniform time intervals available were those derived from astronomical observations of the rotation of the earth relative to the fixed stars, corrected to the orbital motion of the earth about the sun. This orbital motion of the earth is the basis of *Ephemeris Time*. It has been measured with a probable error of 2 parts in 10^9 in a period of three years. Higher precision is expected for longer measurement times.

In 1956, the second of Ephemeris Time was adopted as the fundamental unit of time by the International Committee of Weights and Measures; this action was confirmed by the General Conference on Weights and Measures in 1960. Also, steps were taken by the Conference toward the adoption of an atomic standard for time interval, because the precision of measurement for the atomic standards is two orders of magnitude better over a 2-minute period than astronomical measurements made over a period of 3 years.

A time scale approximating Ephemeris Time can be made immediately available by the use of atomic standards, quartz oscillators, and counters. In terms of the Ephemeris second, the frequency of the cesium transition is experimentally found to be 9192631770 $\pm$20 cps. The probable error ($\pm$20 cps, or 2 parts in 10^9) results from the limitations on the precision of the *astronomical* measurements. The frequency of the transition is assumed to be exactly 9192631770 cps for the purpose of maintaining constancy of broadcast frequencies.

Measurement of a frequency or a time interval in terms of the cesium transition can be made with a precision of $\pm$0.2 cps and is not limited by the instrumental difficulties involved in astronomical observations. However, it does not supplant the present definition of a scale for time based on the uniform apparent motion of the sun.

Report based on (1) *a technical report from the National Bureau of Standards and* (2) *abstracts from article "Precision Frequency Control for Military Applications," by E. A. Gerber and J. M. Havel of United States Army Signal Research & Development Laboratory, Fort Monmouth, N. J. The latter article appears in full in the IRE Transactions on Military Electronics, Vol. MIL-4 No.-4, Oct.,* 1960, *Institute of Radio Engineers,* 1 *E.* 79 *St., New York* 21, *N. Y.*

TABLE 1—PRECISION FREQUENCY STANDARDS

Device	FREQUENCY OF RESONATOR	ACCURACY**	STABILITY	WEIGHT (Pounds)
Precision crystal oscillator (commercially available)	1 Mc	$\pm 1 \times 10^{-8}$*	3×10^{-9} per month	20
Precision crystal oscillator (experimental)	2.5 Mc	$\pm 1 \times 10^{-8}$*	2×10^{-10} per month 2×10^{-10} per second	25
Cs-Beam frequency standard (commercially available under the name "Atomichron")	9193 Mc	$\pm 2 \times 10^{-10}$	2×10^{-11} per day. No measureable long term drift	500 - 800 (commercial Model 1001)
Ammonia Maser (experimental, portable, with limited coolant supply)	23870 Mc	$\pm 1 \times 10^{-9}$	1×10^{-11} per hr 2×10^{-10} per sec	40
Gas-Cell (Rubidium 87, experimental)	6835 Mc	$\pm 1 \times 10^{-9}$	1×10^{-10} per month	30

*Crystal manufacturing tolerances only.
**Relative deviation from an accepted frequency.
***Maximum change in frequency during a specified time interval.

Experiments at the NBS Boulder Laboratories demonstrate that cesium-beam devices of rather modest length (55 cm between the oscillating fields for the shorter of two machines used) can have precision of ± 2 parts in 10^{12} for measurement periods of a few hours. The frequency difference between these two machines is 1.0×10^{-11}. This frequency difference has remained within $\pm 2 \times 10^{-12}$ over 9 months. Fig. 1 shows the NBS-II cesium-beam device.

Radio transmissions controlled by the Bureau's master quartz oscillators are being monitored with these cesium-beam frequency standards. Corrections for the 60-kc standard frequency broadcasts from NBS radio station WWVB (formerly KK2-XEI) at Boulder, Colorado, are being made each week and are available on request from the Broadcast Services Section at the Bureau's Boulder Laboratories. Corrections for the 20-kc transmission from NBS station WWVL also will be available.

RECENT years have brought much progress in the utilization of atomic and molecular microwave spectral lines for frequency control purposes. The high invariance of their center frequencies, which are natural constants, and their very high Q-values, make some of these lines particularly attractive.

The frequency of any spectral line is proportional to the energy difference between certain discrete quantum states of an atom or molecule. This energy difference is either emitted or absorbed, depending on whether the particle makes a transition to a lower (unexcited) or higher (excited) energy state, respectively.

Three different types of atomic and molecular frequency standards have evolved during the past few years—the cesium beam standard, the ammonia maser, and gas-cell devices.

Cesium-Beam Standard

The cesium-beam standard uses a hyperfine transition between two particular energy states in Cs^{133} atoms, caused by the interaction between the magnetic moments of valance electron and nucleus. Fig. 2 shows the principle.

A beam of Cs atoms is emitted from an oven and passes through an inhomogeneous magnetic field where the beam is split according to the states of the atom. Atoms in the lower energy state of the transition pass through a cavity which is excited by an oscillator whose frequency is derived from a high-precision crystal. If the frequency of the oscillator is equal to the desired cesium transition of approximately 9193 Mc, then the atoms can absorb energy from the microwave field in the cavity, thus reversing their magnetic polarity so that they are deflected back to the axis during passage through the second magnetic field. The atoms then will hit a hot wire which ionizes them. A correction voltage for the driving oscillator will be supplied if the number of atoms hitting the detector decreases, i.e., if the frequency of the excitation field deviates from the atomic frequency.

The limiting factor for the sharpness of the line and, thus, for the Q, is the time τ which the atom or molecule has available for interaction with the microwave field, so that $Q = f/\Delta f \cong f \times \tau$. The transit time, τ, depends on the velocity of the particles in the beam and the length of the microwave cavity.

Recording the beat note between 2 standards for 72 hours (at USASRDL) resulted in a stability of 2×10^{-11}.

Efforts to increase further the precision in atomic-beam standards have been going in two directions, to a large extent under Signal Corps sponsorship: first, the "broken-beam experiment" to increase the transit time τ and with it Q[53] and, secondly, studies of molecular spectra in the millimeter range to be

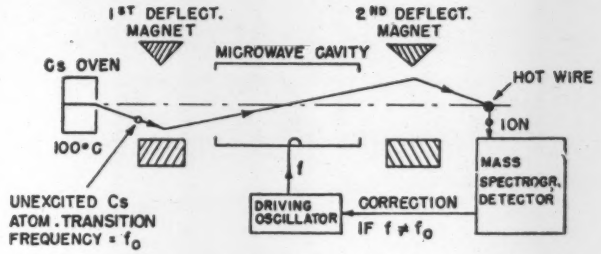


FIG. 2. CESIUM-BEAM standard.

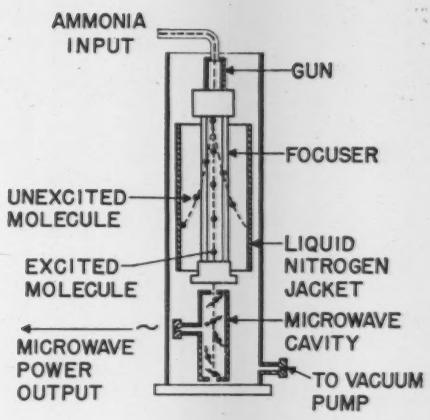


FIG. 3. AMMONIA maser.

able to increase the numerator in the fraction $f/\Delta f = Q$[53].

The emergence of practical cesium atomic-beam frequency standards, with their inherently high accuracy, has stimulated several military applications requiring remotely located synchronized clocks with a precision of ±1 microsecond or better. The problem of synchronizing clocks at great distances and maintaining this synchronization for extended periods of time prompted USASRDL to initiate Project WOSAC (World-Wide Synchronization of Atomic Clocks). This project, undertaken in cooperation with the U. S. Air Force, U. S. Navy, Harvard University, and the British Post Office, is expected to prove the practicability of synchronizing remote clocks by the clock transportation method, and maintaining the synchronization of these clocks by phase tracking VLF transmission signals controlled by a master clock. A recently completed phase of this experiment, using the clock transportation method, demonstrated that two clocks, located approximately 1000 miles apart, could be synchronized and maintained in phase to within 0.2 μsec for 32 hours.

Ammonia Maser

Though cesium-beam standards give the higher accuracy and are best suited for long-term and ground application, the maser looks promising, especially for missile-borne use, due to its high short-term stability, inherent ruggedness, and smaller size. It was first described by Gordon, Zeiger and Townes, and uses an electric dipole transition in ammonia, namely, the (3,3) inversion line, occuring at about 23,870 Mc.

Fig. 3 illustrates the principle. A beam of NH_3 molecules passes through a state separator (focuser) which removes the molecules in the lower energy state from the beam. It is now comprised only of the higher-energy-state molecules, which enter a microwave cavity tuned to the transition frequency. There, the molecules make the transition to the unexcited state, emit radiation and sustain oscillations.

The maser does not possess the high inherent accuracy of a cesium-beam standard, mainly because the resonance frequency of the cavity has a definite influence upon the maser output frequency. Much work has been accomplished, in USASRDL and elsewhere, to reduce this so-called cavity pulling effect, as well as the influences of other parameters on the output frequency.

In order to reduce the K-band frequency of the maser to the desired value in the VHF range, miniaturized frequency translators have been developed at several places. Fig. 4 shows the schematic of the double-loop equipment of USASRDL. A klystron is phase-locked to the maser, and a harmonic of a quartz crystal oscillator is phase-locked to the klystron signal. Any instability of the 30-Mc reference oscillator cancels out. A one-loop translator was developed by the Diamond Ordnance Fuze Laboratories. It is based on the coherent multiplication of the quartz controlled oscillator to a frequency in the K-band employing a varactor diode.

Gas-Cell Devices

Though a gas-cell standard does not possess the inherent accuracy of a cesium-beam standard, it can be built in a small size.

In contrast to the cesium-beam standard and the maser, this type of atomic standard does not employ a beam, but uses the resonating gas enclosed in a small container. A considerable amount of work on gas cells has been accomplished in several places, some sponsored by USASRDL. Most effort has been concentrated on atomic rubidium or cesium undergoing the same type of transition as used in the cesium-beam standard. Sharp spectral lines are created when the gas atoms collide elastically with a neutral (buffer) gas, such as argon, helium or neon. These collisions slow down the effective velocity of the atoms from the higher value of a straight thermal flight to the lower value of crisscross flight encountered in diffusion processes. The necessary change of the Boltzmann distribution for the hyperfine microwave transition under con-

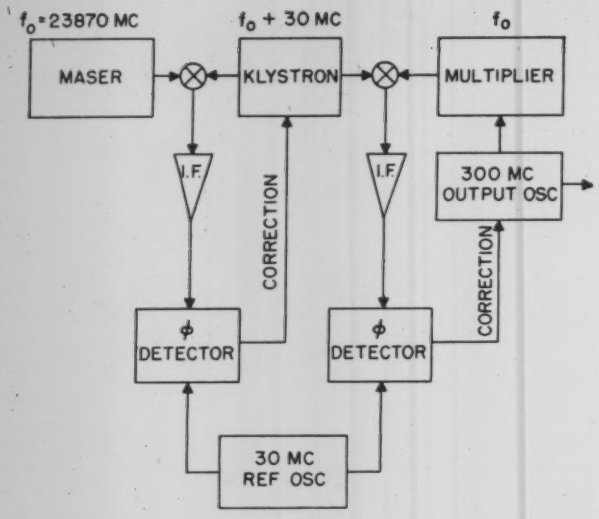


FIG. 4. DOUBLE-LOOP frequency translator for the maser.

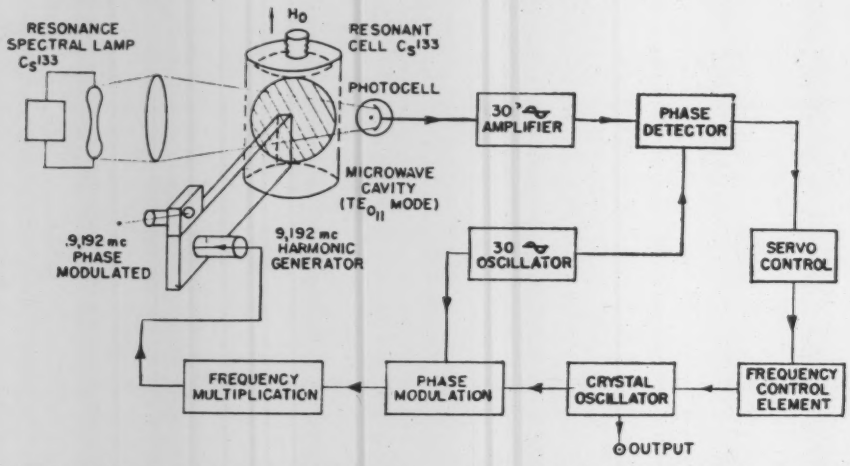


FIG. 5. GAS-CELL atomic clock using optical pumping and optical detection. (Courtesy M. Arditi, ITT Laboratories).

sideration is effected by the so-called method of *optical pumping*.

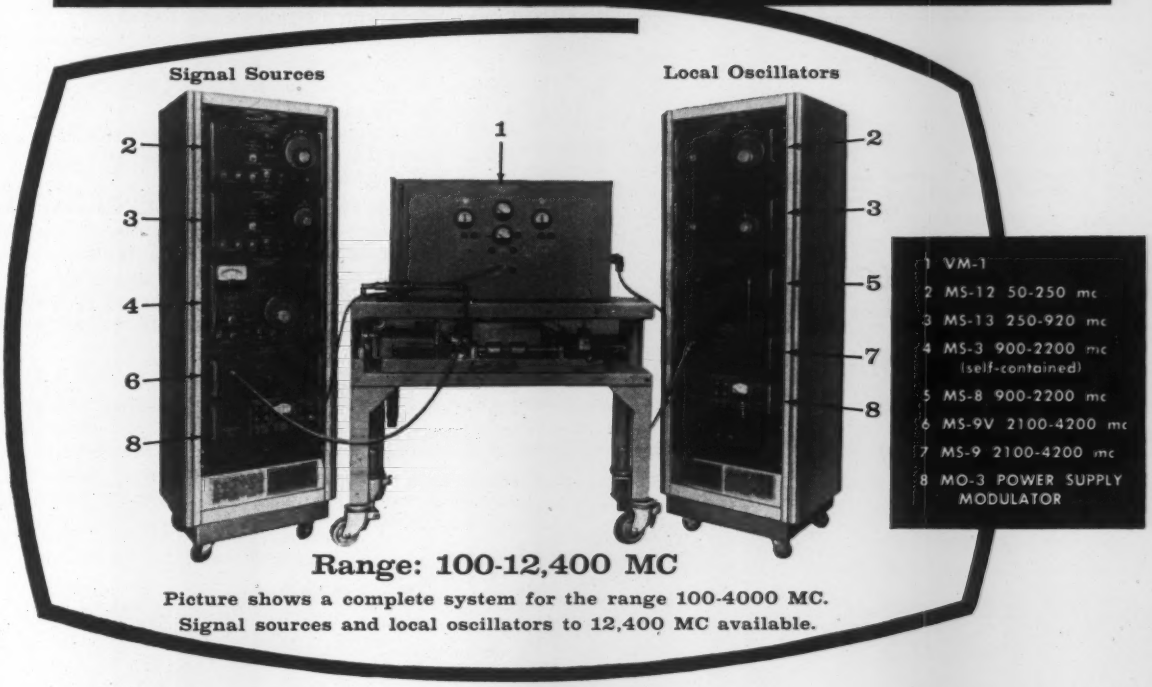
In optical pumping, the gas cell is illuminated with suitably polarized light of a wavelength corresponding to an optical transition of the atoms. The absorption and subsequent emission of this light can result in a rearrangement of the atoms within the group of hyperfine states belonging to the optical ground state, thus resulting in hyperfine states responsible for the microwave transition. The intensity of the pumping radiation absorbed or scattered by the gas cell changes when the desired microwave transition occurs. This offers a convenient way of detecting the microwave resonance with a high signal-to-noise ratio.

Fig. 5 shows the schematic of a typical gas cell standard using Cs^{133} and light absorption for the indication of resonance. A crystal oscillator is phase locked to the resonance frequency of the atomic transition. One serious disadvantage of a gas cell is the fact that the buffer gas produces a shift of the center frequency of the hyperfine transition, and this shift is a function of temperature and pressure. Fortunately, different buffer gases produce frequency shifts in opposite directions, and mixtures of these gases can be found which produce only a small shift within a large range of pressure or temperature variations. With optical detection, a mixture of 12% neon and 88% argon as a buffer gas, and a temperature stability of 0.1°C, data as indicated in Table 1 can be obtained.

Pres. .....WILLIAM K. GEIST, W. K. Geist Co., Los Angeles, Calif.
V. Pres. .....HOWARD KEMP, Borg-Warner Controls, Santa Ana, Calif.
Secty. .....FRANK THOMA, General Radio, Los Angeles, Calif.
Treas. .....A. K. EDGERTON, Western Instruments, Burbank, Calif.

Complete Attenuation Measuring System

VM-1 by WEINSCHEL



Range: 100-12,400 MC

Picture shows a complete system for the range 100-4000 MC. Signal sources and local oscillators to 12,400 MC available.

Makes a 70 DB measurement with 0.02 DB precision

This is the only complete working system commercially available from one source which offers standards laboratory accuracy over such a great dynamic range. Each component is designed for compatability, resulting in optimum systems performance. This Weinschel system does perform:

A 60 db measurement with an accuracy greater than 0.12 db starting with 20 millivolts (—21 dbm)

A 120 db measurement with accuracy greater than 0.4 db starting with 2 volts (+19 dbm)

Saves Time of Skilled Personnel

The VM-1 is **direct reading,** easy to use. No calibration curves or correction charts are needed. This **ease of operation** enables normally skilled personnel to perform much of the work and still save many hours both in setting-up time and in measurement time.

† Patent applied for.

Typical example of time saved for making eight 10 db step measurements of signal generator output attenuator or an external variable attenuator:

	Old Method		Using Weinschel VM-1	
	Time	Personnel Required	Time	Personnel Required
Set-up time for one frequency.	1 day	Highly skilled with experience	15 min.	Normally skilled operator with one week initial training.*
Measurement time	30 min.	Highly skilled with experience	3 min.	No technically skilled operator required.

* Installation and training at customer's laboratory by a Weinschel specialist is included with each system purchased.

Typical Uses of the VM-1

The VM-1 attenuation measurement system is designed for use in **standards laboratories.** It can also be used in **precision testing** on a 100% basis in certain **production** applications where state-of-art accuracies are required (e.g., radar fuzing systems, guidance and satellite communications systems). It is also used in the **calibration** of output attenuators of **signal generators.**

For complete information on the VM-1 Attenuation Measuring Systems, call or write the Application Engineering Department, Weinschel Engineering Company.

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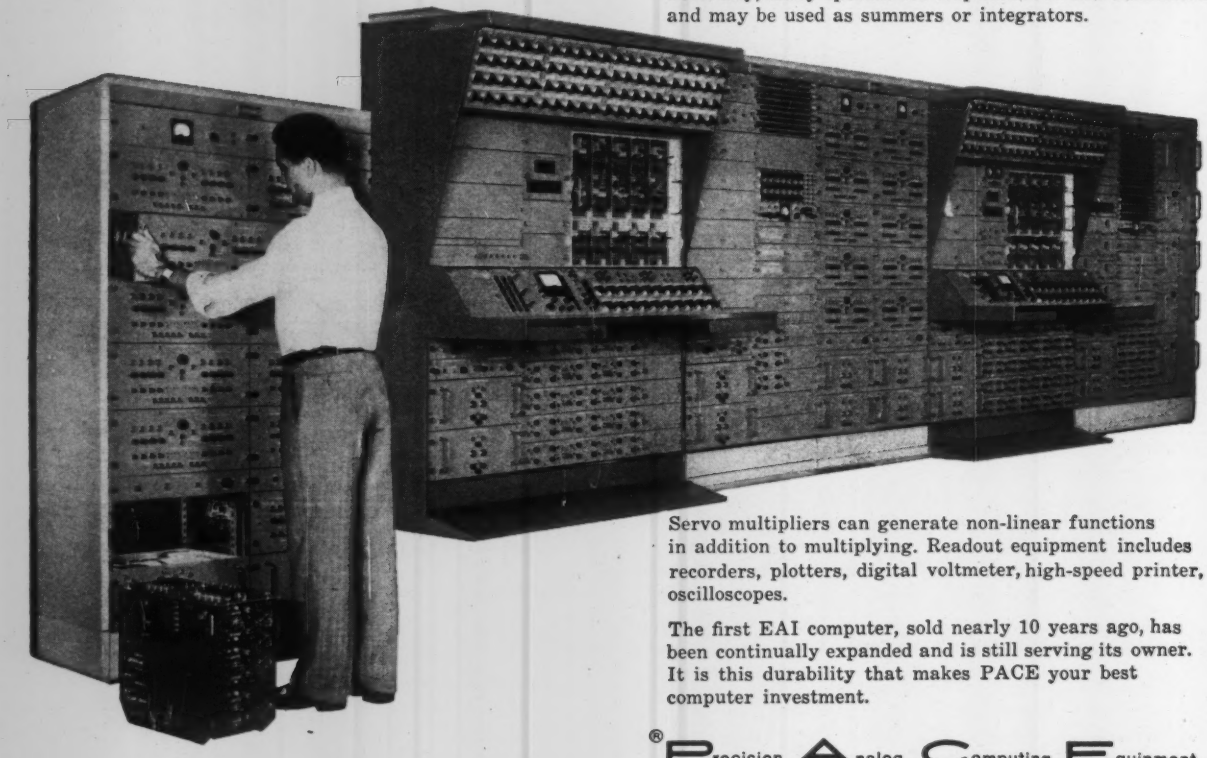
MODULAR DESIGN PROVIDES FLEXIBILITY AND ECONOMY

The PACE 231R is one of the most versatile, flexible computers ever designed. It is composed entirely of standard production line components. As a result, you have the benefit of a custom-built computer without the costs of special design.

You can start with a single console containing 40 operational amplifiers and 20 coefficient potentiometers (or less)—then expand by adding standard plug-in components, stock harnesses, and hardware. No soldering, no cable lacing, no metal work required. A single console can contain up to 80 operational amplifiers, 150 coefficient potentiometers and additional control and operational components.

Large 3450 hole pre-patch panel provides terminations for up to 100 amplifiers, 150 potentiometers, and many assorted linear and non-linear components. When your demands exceed the capacity of the basic console, components can be added in groups—housed in compact, rugged racks which blend perfectly with the basic console.

You can choose from the world's widest line of computing components and accessories. For example, EAI offers 61 different types of servo and electronic multipliers and a wide variety of fixed function generators for performing sin x, cos x, x^2, log x, x^4 and other commonly encountered mathematical operations. For added flexibility, many operational amplifiers are non-committed and may be used as summers or integrators.

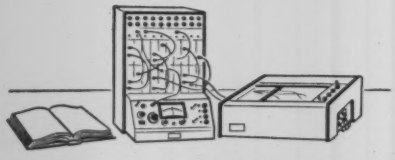


Servo multipliers can generate non-linear functions in addition to multiplying. Readout equipment includes recorders, plotters, digital voltmeter, high-speed printer, oscilloscopes.

The first EAI computer, sold nearly 10 years ago, has been continually expanded and is still serving its owner. It is this durability that makes PACE your best computer investment.

®Precision Analog Computing Equipment

Outstanding opportunities for engineers with proven ability—resumes invited.



New solid-state computer and desktop X-Y plotter.

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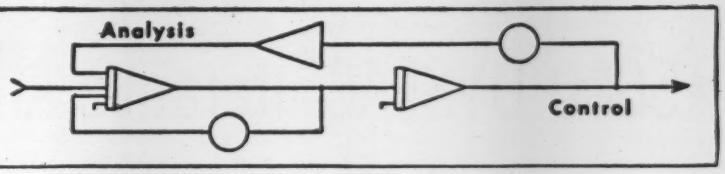

Newsletter

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Suzette McLeod, SECRETARY

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Bits

This month under **Pieces** we report the January 12th meeting of the Western Simulation Council, held at System Development Corporation in Santa Monica. Included are abstracts of talks on "Digital Simulation of Large-scale Man-machine System," as follows: "Introduction to SDC" by **H. Harmon;** "Simulation Methods in Man-machine Simulation Research" by **L. T. Alexander;** "Use of Simulation in Training" by **M. G. Holmen;** and "Role of Manned Simulation in Operations Research" by **W. A. Steger.**

Also under **Pieces** we present an almost complete talk excerpted from the Eastern Simulation Council's meeting at IBM-Kingston on February 20th on "Circuit Simulation by a Direct Approach" by **R. W. Boucher** and **C. T. Lecher.**

This, with another installment of **"Analog Techniques," SCI Activities,** a piece of **Info,** and three **"He Wents"** (two current, one outdated) complete this month's *Newsletter.*

Pieces

WESTERN S/C MEETING OF 12 JAN ON "DIGITAL SIMULATION OF MAN-MACHINE SYSTEMS"

About 80 visitors, not counting several representatives of our host organization—the System Development Corporation—attended the January 12th meeting of the Western Simulation Council in Santa Monica, Calif. to participate in a discussion of "Digital Simulation of Large-scale Man-Machine Systems."

Harmon on SDC

By way of introducing both the topic and his own company, **Harry Harmon,** Manager of the SDC Systems Simulation Research Laboratory, gave us some interesting facts, among them:

The System Development Corporation is non-profit, organized for scientific and educational purposes to contribute to the public welfare and security of the United States. Its present work evolved from an original research program of *group interactions and human factors affecting man-machine system research* which was conducted in the RAND Corporation's Systems Research Lab between 1951 and 1953. From the Laboratory's studies of information-processing centers, employing an air defense direction center as a prototype, was developed the system training program now in operation throughout the United States (including Alaska) and Canada.

SDC employees exceed 3,600, about half of them with college degrees. Of the latter, about 15% are at the doctorate level. Skill specialties are in the fields of Operations Research, Human Factors Engineering, and Computer Programming. However, in the conception and design of man-machine systems, individual skills are subordinated to the scientific interdisciplinary team approach.

SDC is a member of the SAC Control Systems Project team, which is designing a high-speed data transmission, processing and display system for planning, directing, and controlling the world-wide operations of SAC.

The income which SDC derives from contract operations is used in furthering a program of research in the national interest. In the early days, research activities grew somewhat like Topsy as the company developed, but later a more comprehensive and coordinated research program was conceived; SDC decided to create a multi-million dollar computer-based general-purpose laboratory for the study of man-machine systems.

In addition to basic research on systems through simulation, the System Simulation Research Laboratory will also be available for research and development work on other ex-

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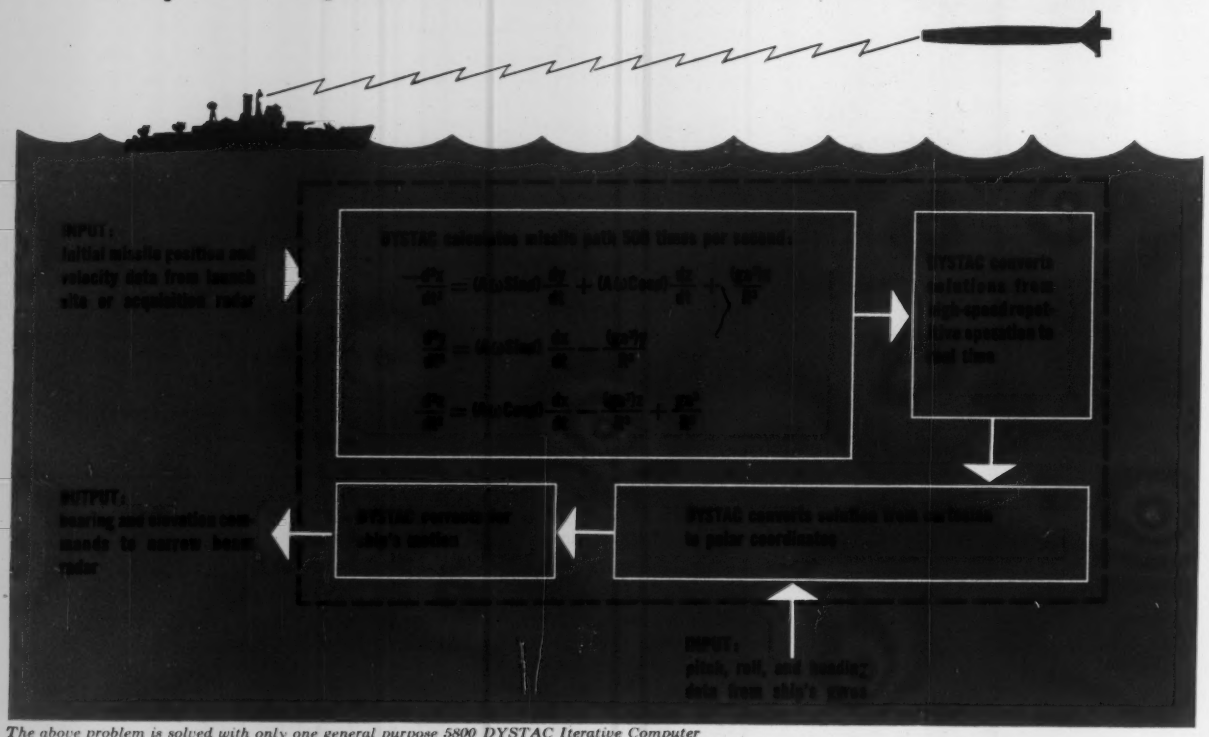
5800 DYSTAC® Iterative Analog Computer Keeps Shipboard Radar Locked on Missile

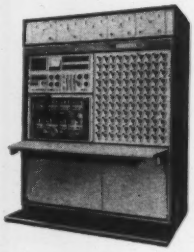


The above problem is solved with only one general purpose 5800 DYSTAC Iterative Computer

Dynamic memory and high-speed repetitive calculations in DYSTAC provide drift-free solutions to problems over real time periods of almost any length! The missile in this problem may be in range for many minutes . . . but DYSTAC-directed radar stays locked-on, despite the passing of time, and the various motions of missile and ship.

The 5800 DYSTAC Iterative Analog Computer is unique, combining the advantages of analogs with those of digitals. It solves equations, such as those shown above, simultaneously in high-speed repetitive operation (up to 500 solutions per second) as well as in real time. Its dynamic memory permits direct plotting from high-speed repetitive operation without rescaling. It can store data or continuous functions, start and stop its program by comparing new results with memorized information, reinsert data or functions during calculations, and time-share computer components. In addition, DYSTAC can be used as the most accurate general-purpose analog computer ever built.

Whether your interests lie in real-time tracking, process optimization, structures, operations research, aerodynamics, or any of many other areas, the 5800 DYSTAC Iterative Analog Computer offers unprecedented computer capability. A detailed report, "Applications of DYSTAC Computers to Missile Tracking Problems", is available on request. For a copy, or more detailed information on DYSTAC, simply write or call.



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isting SDC contracts, and—at a low priority—the doors of the laboratory will be open to researchers at universities and other non-profit organizations having need for such facilities.

The staff immediately associated with planning and building SSRL forms a small inter-disciplinary team of Operation Research scientists, Human Factors scientists, an engineer, and a small group of computer programmers. By August of this year SSRL should be ready for their initial research project: the study of a terminal air-traffic-control system operating in a post-1970 air environment.

Alexander on Man-Machine Simulation Methods

Second paper of the day was "Simulation Methods in Man-Machine Simulation Research" by **Lawrence T. Alexander** (SDC SSRL). The author's abstract follows:

"Scientists who are engaged in system research often have difficulty communicating with one another about the use of simulation as a research technique."*

"A good deal of confusion and misunderstanding results because the word "simulation" is currently applied to a wide variety of research techniques. In this paper an attempt is made to reduce this confusion by describing a particular kind of simulation, called "*bioscopic simulation*," and comparing it with other simulation techniques.

"Bioscopic simulation is a technique for conducting research on the problems which arise from the design, development, training, and evaluation of man-machine systems. It is distinguished from other simulation techniques primarily by the fact that live subjects are incorporated in the system model. Bioscopic simulation is particularly useful for studying:

1. Systems in which human behavior is a significant determiner of output efficiency or reliability;

2. Systems in which people are the main agency by which adjustment or adaptation of the system to its changing environment is accomplished;

3. Systems in which the human behavior exhibited during system operations is considered to be an important object of study.

4. Systems in which interactions among components or sub-systems are major contributors to the variance in system output.

"In bioscopic simulation models, no simplifying assumptions about the properties of human behavior are made. Instead, human behavior exists explicitly as part of the operations of the system. Inputs to the system from the environment usually occur in real time, or segmented real time, and the fidelity with which elements of the environment are represented is directly related to their impact upon the behavior which is being studied. Almost all aspects of the environment can be controlled, manipulated, and replicated, but to a lesser degree than with stochastic or mathematical models.

"One of the main problems which arises in using bioscopic simulation is the cost and time required to replicate an experimental run. Better experimental design and more selective data collection and analysis techniques will help to alleviate this situation."

Holmen on Simulation in Training

Dr. Milton G. Holmen, Manager of Air Defense Operations of SDC, was the third speaker. His abstract of his talk "Use of Simulation in Training" follows:

"This talk will be limited to the use of simulation and the training of military systems having large numbers of men and machines. Simulation has been a tool in training of military organizations for many years. In military systems in which the equipment is relatively simple, the simulation tends to be fairly easy to achieve. For example, in training infantry units prior to World War II, most any beach could be used to simulate an enemy beachhead. Mortars could be simulated by using logs or heavy pieces of pipe, and rifles by appropriately shaped sticks. Small sacks of flour were frequently used to simulate small bombs.

"As military systems became somewhat more complex they reached a point where realistic simulation was very difficult. An armored unit, for example, cannot effectively practice rough terrain tactics without real tanks. The early anti-aircraft units operating without radar could hardly practice their use of sound locating devices, searchlights, etc., without the presence of real aircraft overhead.

"In the first of the systems described above, the equipment is designed to extend the range of a man's receptor and effector mechanisms, and the environment within which he operates is a familiar one. In the second case, the man and the machine are more equal partners, and the environment is a less familiar one, e.g., in the air and under the water.

"In current military systems the machines are in many ways predominant, with the men serving a decision-making and monitoring function. There is no direct interaction between most of these men and the actual environment of combat. They no longer see aircraft, they see radar blips; or more likely, aircraft track information consisting of radar blips acted upon by a number of computer processes. Simulation in such systems may be expensive, but it has the offsetting virtue of being so realistic that the human operator cannot distinguish the synthetic signals from real ones, his only connection being switch setting or display information specifically designed to prevent confusion between the real and synthetic environments.

Eight general points should be made about the use of simulation for training in the more complex systems.

1. The difficulty of development of the simulation procedures is a function of the complexity of each unit.

2. Cost of operation of such a simulated environment is primarily a function of the number of units in the system.

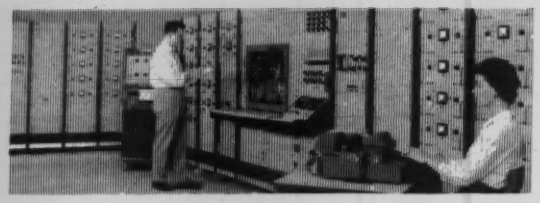
3. Training of all of the systems requires synthetic inputs only at the periphery, whereas training parts of it requires a larger number of input sources in order to train the same number of men, due to the requirement for inputs at all interfaces.

4. Effective training requires control of the input stimuli, and detailed knowledge about these stimuli by the persons conducting and receiving the training.

5. Also required for system improvement is knowledge of the actions taken within the system. This requires fast and accurate recording systems, and frequently requires data reduction procedures as well.

6. Ordinarily the most difficult simulation job in training a complex system is the simulation of inputs to the system which are the direct re-

*Though deleted from his abstract, we recall that at about this point the author observed that the tower of Babel was an early example of a project that fell apart as a result of communication difficulties!—Ed.



SPEAKING WITH EASE®

An up-to-the-minute report on computer technology

How Good Maintenance Planning Increases Computer Performance

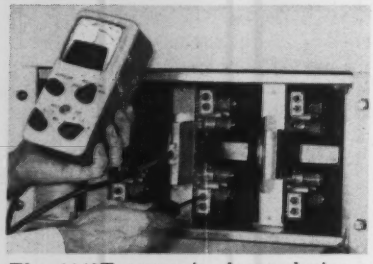
As problems of industry and research become more complex, a greater need is developing for computers that can handle these problems as easily and simply as possible. Designers of EASE computers have seen this need from the beginning, and have produced equipment that's not only highly accurate and dependable . . . but highly serviceable as well.

Where Design Plays an Important Role

The time lost to maintenance is as real as the time spent in setting up and running the problem. We have found that good design engineering can reduce downtime by incorporating three important features into a computer. These we call *reachability, undisturbability,* and *interchangeability.* That's sort of a mouthful all together, so let's take them one by one.

Reachability. This means that modules, such as multipliers and amplifiers, can be reached without rummaging around in the back of the computer. EASE engineers have constructed computers so that all printed circuit modules are serviceable from the front. All you have to do is open the door of the chassis and slide out the module. Since the module plugs directly into the computer, you actually have nothing to disconnect. The assemblies located in the back require only occasional servicing, such as coefficient potentiometer assemblies and control circuits. These are removed by disconnecting a simple plug connection.

Undisturbability. This is the ability to test modules without disturbing their connections or moving them to a test environment. In this way errors due to discrepancies between test circuits and operational circuits are ruled out. EASE solves this problem in two ways: by arranging most computer modules so they can be tested without breaking electrical connections, and by providing an instrument for testing essential performance characteristics. The tester used is the 1148T—a battery-operated, transistorized, plug-in device that is simple to operate and small enough to be hand held.

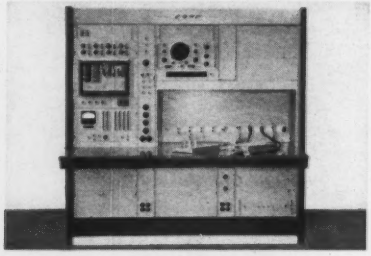


The 1148T tester is shown during a check-out of an amplifier module.

Interchangeability. This means that units of modular design can be interchanged. Thus in an EASE computer, a multiplier amplifier can become a function generator amplifier simply by pulling the amplifier module from one chassis and inserting it into another. These amplifiers are not only interchangeable, but identical to the standard operational amplifier. The wiring of the chassis determines the function of the module it encloses. Different models of function generators or multipliers can also be interchanged within a given chassis. This feature of interchangeability has obvious advantages: the speed with which you can replace a malfunctioning module, and the space and maintenance you save by eliminating special maintenance techniques.

A Test Computer that Is Complete

For medium to large installations, EASE makes available the 1133T—an off-line maintenance computer designed to check every operational unit of standard EASE computers. It can also perform nonstandard checks. If you're interested in learning more about it, let us know. The 1133T product bulletin is available and we'll be glad to send it to you.



The 1133T test computer.

An Automatic System that Speeds Checkout

EASE offers the most advanced technique for computer testing in an automated system used for maintenance as well as programming. DO/IT, more formally known as the "digital output/input translator," is a system for entering and retrieving information via typewriter and punched tape. An operator, scanning the printed record, can immediately pinpoint errors in patching and mechanization—in addition to errors created by possible faulty components. Programmed maintenance tape is available for use with the DO/IT, along with prewired check-out patchboard.

Other Maintenance Services

EASE also offers field engineering assistance, a factory service group, installation and service policy, spare parts leasing, frequent maintenance bulletins, and training schools for operators and technicians . . . all of which add up to a highly integrated maintenance program which we feel will give you the best performance from a computer facility.

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sult of outputs from the system, i.e., the simulation of radar returns from fighter aircraft under the control of an air defense system.

7. The greatest single source of improvement will ordinarily come from making things which are normally invisible to all or most of the persons in the system become visible, so that the effect of every action taken can be observed by a large number of people. This is the plan of "feedback" in the system training program.

8. Finally, the acceptance of simulation on the part of the persons being trained requires verisimilitude, by which I mean that the significant aspects of the training environment must be accurately simulated, (radar measures the correct size and moves in a realistic fashion, etc.) and the inputs must appear at the appropriate time, and proportional relationship to each other.

"Simulation equipment and methods are appropriately used in the training of complex systems. That training is frequently more realistic than if most of the inputs were real. Use of simulation in this case has the advantage that large quantities of inputs can be simulated, enemy strategies in military systems can be simulated without loss of security control; and actions, which in a live environment would result in loss of life and property, can be simulated at low cost, with complete safety."

Steger on Manned Simulation in Operations Research

Wilbur Steger, Chief Economist, Logistics Simulation Laboratory of the Rand Corporation, Santa Monica, the next speaker on the program, has been kind enough to supply us with the following abstract of his talk:

"Developing the detailed operations and support plans for a new Air Force weapon system is a very difficult task: numerous agencies are involved, many uncertainties exist, development planning and weapon operations are becoming overlapping activities, and billions of dollars may be involved. The hypothesis examined in this talk was that an abstract, yet highly detailed computer-assisted manned simulation of a significantly large management segment of the weapon system, *as it might* look in its operational phase, would greatly assist weapon planners during the weapon's *planning* phase, and would yield considerable net benefits to the overall program. The argument is made that simulation will not only produce a better management system earlier but it will permit the planners to adjust the other resources (maintenance, supply, transportation, etc.) provided for the weapon system so that they are compatible with the environment and the control system.

"An example of such a study, the second major experiment of the RAND Logistics Systems Laboratory (LP-II), was described. This experiment has produced techniques of support planning for new weapons which may represent major advances in such activities. This talk described the conditions under which support planning must be performed in the present and future military environment and the experience of LP-II in performing such planning for an ICBM weapon of the 1963-65 time period. The specific planning alternatives for the first-generation ICBM weapon system, considered during the LP-II exercise were: ICBM basing; support-operation interactions, such as checkout policies and the impact of training; alternative management control systems; and different supply, manning and equipping policies. System costs and effectiveness, measured by the percentage of the force that could be successfully fired, are estimated for each of several ICBM basing and management configurations. The LP-II experience indicated the importance of using humans in computer-assisted simulations involving managers making important but complex-decisions regarding support and operation of the weapon system.

"Other relatively novel features of LP-II were: its large scope but sufficient detail to aid individual, specific planning divisions; the production of both cost/effectiveness and gaming-type "qualitative" results; and new methods for replicating a somewhat hostile nature, realistically, in response to the participant's decisions. Some of the difficulties in using this technique were, also, discussed. Finally, a proposal was made suggesting the role that manned simulation might play in the weapon system planning process."

CIRCUIT SIMULATION BY DIRECT APPROACH

R. W. BOUCHER

C. T. LECHER

Second "Piece" of this month's *Newsletter* is an article which we choose to publish almost as received: "Circuit Simulation by a Direct Approach" by **R. W. Boucher** and **C. T. Lecher**, both of the IBM Command Control Center, Federal Systems Division, Kingston, New York. The authors presented this paper at the Eastern Simulation Council meeting held at IBM-Kingston on February 20th, and we have selected it for presentation here, somewhat out of context—but almost complete—because we believe that the technique presented will become more and more useful and important as the current evolution in electronic components continues. Besides, we love to report useful applications of analog computers developed and recommended by "look who!"—Ed.

Circuit Simulation has been achieving importance in the field of electronic design. In the past a circuit designer would decide on a general configuration for a circuit, make a few DC computations at his desk, and build a breadboard model of the circuit. The breadboard model then can be tested readily and, by systematically substituting various size components, optimum operating characteristics can be found.

Circuits can be studied on computers. However, this technique requires an understanding of all of the elements in the circuit. The simple devices such as resistors, capacitors and aircore inductors are well-known

and provide no problems when defining them mathematically. However, devices such as iron or ferrite core transformers, transistors, and distributed-parameter systems are not understood as well. As a result, these components are not well defined or adequately described for computer analysis. For this reason, it has been easier to breadboard and optimize a circuit rather than attempt to understand all of the components of the circuit and perform a computer study.

Currently, the electronics industries have been developing a variety of circuits that are not easily breadboarded and modified. Thin-film circuits, thick-film circuits, and diffused semiconductor circuits are difficult and time consuming to produce in the laboratory. The values of components or portions of the circuits cannot be changed without building another complete circuit. Lumped-parameter models (using standard components) have not always proved satisfactory because the distributed effects are not the same as found in the original circuit, and cannot be controlled easily. An example is the cryotron, which has no real lumped-parameter equivalent.

If computers are to be used to study circuits, it is not necessary to train programmers to understand circuit operation. Rather, it is better to make effective use of the knowledge of the circuit designers by using suitable programming techniques for the computer. It is not required that the circuit designer have an extensive math background; however, it is desirable that he have an understanding of integral calculus. The fact that the circuit designer is familiar with, and always tends to reduce or interpret everything in terms of, equivalent circuits is as useful as a thorough knowledge of different equations.

The circuit designer formulates his problems by laying out the circuit with all of the components. Components that are simple R's, L's and C's provide no problem. Devices such as transformers, transistors and diodes can be transformed into R, L and C networks containing "ideal" transformers, voltage generators and current generators. Under operating conditions the value of these equivalent elements may change as the operating parameters change. In the case of purely distributed-parameter devices such as transmission lines, the circuit designer looks at its physical construction and describes it by means of a simple R, L or C ladder network. (The results are effectively the same as a mathematician taking the partial differential equation for a transmission line and finite differencing the equation into a system of simultaneous second-order differential equations.) The circuit designer also considers and adds parasitic effects such as interwiring capacitance, effective inductance of wiring, and leakage resistance of components. Such an equivalent circuit, as elaborate or as crude as it may be, is essentially a differential equation which describes the operation of the original circuit.

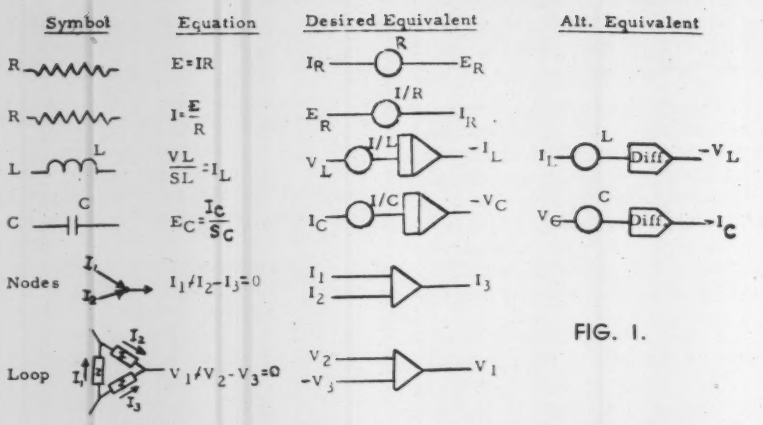

FIG. 1.

The steps the programmer generally takes in simulating the equivalent circuit on the analog computer are:

1. Write the system of differential equations, using either loop or nodal analysis.

2. Scale the equations using best estimates of circuit operation.

3. Draw a computer diagram (flow chart) of the scaled equation.

This is the hard way of doing things. A simple straightforward technique of circuit simulation is to form an "analog computer equivalent circuit" of the equivalent circuit using the following steps:

1. Transpose the equivalent circuit directly into an analog-computer diagram without first writing the circuit equation.

2. Scale the analog computer diagram using circuit component values.

The latter technique has the immediate advantages of:

1. Allowing circuit designers to program with a minimum of additional training.

2. Since circuit equations are eliminated, simple changes in circuit layout do not require starting all over again to change the program.

3. Since scaling was the last step in programming, any errors can be corrected on the computer and with the aid of the computer.

These and other advantages in using the proposed technique will become evident as the technique is described.

We should note here that it is felt that there is nothing really new in the proposed technique except its simplicity. Many papers have touched on parts of the described methods but none have been observed to bring all the methods together. The demands of many analog-computer programmers for new computers that have automatic scaling and automatic programming indicate that there is still a large group that uses the older classical and brute force techniques to set up problems.

This technique has several advantages besides the straightforward manner of programming. Every voltage and current that is indicated in the equivalent circuit is available for monitoring in the computer equivalent. Another advantage is that every R, L and C or their reciprocals are directly and independently available for adjustment. The circuit designer maintains as direct a feel for his circuit as if he were changing components in a breadboard circuit. Also, very little programming effort is required to modify the program if a circuit designer wishes to add or remove components in the circuit in an effort to improve its characteristics.

The analog equivalent is developed starting with the basic R, L and C circuit elements and developing their equivalents (Fig. 1).

In Fig. 1, the alternate equivalents, where given, are not desirable due to the fact that a differential form rather than an integral form of the equation is used. However, the differential form may be useful in setting up early drafts of computer

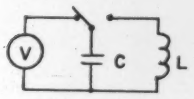

FIG. 2.

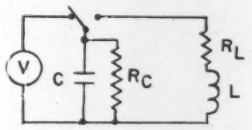

FIG. 3.

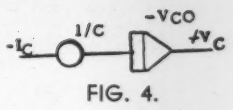

FIG. 4.

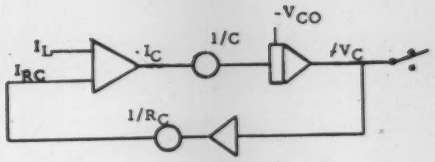

FIG. 5.

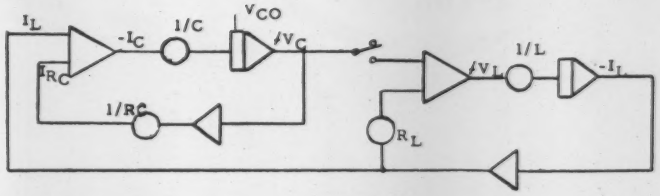

FIG. 6.

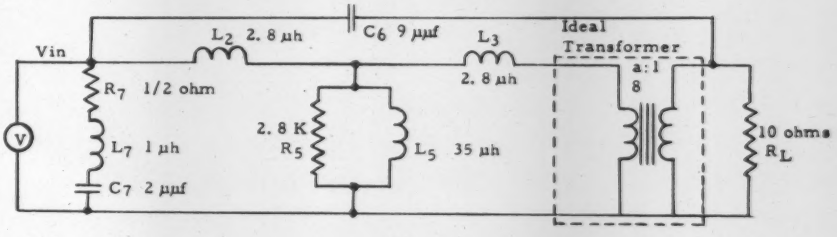

FIG. 7.

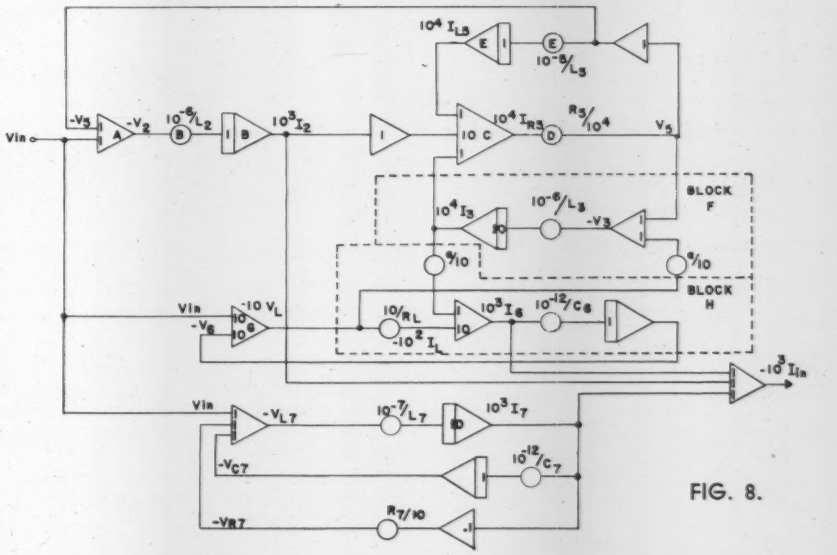

FIG. 8.

diagrams and, in some cases, the alternate equivalent may even be a desirable form to use.

A simple circuit designed to illustrate the use of this table of equivalents is a tank circuit containing a capacitor charged by a power supply and then switched across an inductor by a switch (Fig. 2). The capacitor leakage and the inductor's series resistance, when it is significant, might be accounted for by the circuit of Fig. 3.

If we also consider that the switch might be slow in operation, our computer equivalent will develop as follows: First we take our equivalent of our capacitor (Fig. 4). As V_C is always impressed across R_C, we can add to our equivalent as in Fig. 5, which describes the circuit dynamics during the period the switch is in transit. The amplifier with the unfilled input is the node at which the switch is located. When the switch finally closes on the other side, the voltage V_C is then impressed across R_L and L. Considering that we now have another voltage loop and that we should arrive at the voltage across the inductor so that the desired equivalent form is used, the computer equivalent grows to the circuit shown in Fig. 6.

Larger circuits are almost as easy to develop using the same process.

Another example slightly more complicated than the previous example is an equivalent circuit of a linear step down pulse transformer with a resistive load. The direction of all currents in Fig. 7 are assumed to flow either to the right or down, and the voltage drops are such that they will be consistent with the direction of current.

The type of driving function (current or voltage) for the circuit determines how the transformation of the circuit into an analog equivalent begins (Fig. 8). Current forcing functions require starting at a node and voltage forcing functions require starting with a voltage loop. Starting with the loop involving V_{in}, Z_{L2}, and Z_{R5}, we solve for the voltage V_{L2} assuming that V_5 exists (amplifier A). This choice allows the use of the desired analog equivalent for the inductor L_2. The analog equivalent of L_2 provides the current through L_2 (amplifier and Pot. B). This current is used, along with the currents that will be developed from the desired analog equivalents of L_3 and L_5, to obtain the current I_{R5} from the node (amplifier C). The analog equivalent of R_5 now provides the voltage V_{R5} which was assumed in starting the problem (Pot. D). This voltage is also equal to the voltage across L_5 in the loop involving R_5 and L_5 and, by using equivalent of L_5 (amplifier and Pot. E), the previously assumed current I_{L5} is obtained. The remaining current into the node is obtained from the analog equivalent of L_3. The required voltage across L_3 is obtained using the voltage loop involving R_5, L_3 and the voltage across R_L as reflected through the ideal transformer (Block F). The voltage V_L is obtained using the loops involving V_{in} and V_{C6} (amplifier G). The current obtained from the analog equivalent

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of R_L along with the current I_3 as reflected through the ideal transformer provide the nodal current I_6. Using the analog equivalent of C_6, the current I_6 transforms into the voltage V_6 which had been assumed (Block H). The small R, L, C network across V_{in} is also easily handled if V_{L7} is obtained from the voltage loop. This voltage, using the analog equivalent of L_7, transforms into I_7 which is transformed back into the required voltage V_{C7} and V_{R7} using the equivalents for the impedance C_7 and R_7.

Scaling the diagram is as simple and straightforward as was forming the diagram.

The multiplying factor of a potentiometer is always less than one, and preferably greater than one-tenth. Therefore, the first step in scaling is to multiply each 1/L and 1/C by a power of ten so that the associated potentiometer setting will be between 0.1 and 1.0. A compensating gain is temporarily associated with each of the corresponding integrators. The scaling of potentiometers simulating R, 1/R, and in this problem a and 1/a, is also carried out. However, the compensating gain is moved back into the one or more nearest integrators.

An estimate of the time scale is obtained by taking an average of the exponents of these temporary gains. This number, rounded off to the nearest integer will be used as the exponent of a phantom gain in all of the integrators. If servomechanical components are used in the problem, the slower time scale of the next higher power of ten may be preferred. However, when no servo components are used, the next lower power will work and give a more rapid solution to the problem. In the example a time scale of 10^9 is used.

Using the estimated power of 10 as a phantom gain (in place of the compensating gains previously used) of the integrators, it now becomes a simple procedure to balance all of the loops and calculate the scale factor of the dependent variables. A start in this direction is given as follows. If the maximum value V_{in} is less than 100 volts, then the input needs no scaling and V_2 may be considered at an adequate level. V_2 will transform into 10^3I_2. Multiplying 10^3I_2 by 10 at the node there is an output of 10^4IR_5 which, when multiplied by the R_5 scale factor of 10^{-4}, gives 10^0V_5. This V_5 balances against the V_{in} as required and in addition, when multiplied by the scale factor of L_5 and the time scale in the integrator, transforms into 10^4IL_5, which is required to obtain the 10^4IR_5. Balancing the loops throughout the remainder of the circuit is just as straightforward.

The time scale has been set by the phantom gain in the integrator; the time scale says that

10^9 computer sec = 1 problem sec, or
1 computer sec =
1 problem millimicrosec

The amplitude scale of each of the dependent variables is given on the computer diagram. As an example, one volt out of the integrator that simulates L_2 would equal 10^{-3} amp in the problem, or:

1 volt (computer unit) =
10^3I_2 volts/amp, or
$I_2 = 10^{-3}$ (amp/volt) x
volts (computer unit)

At the amplifier that sums the loop voltages to provide V_2, one volt of the amplifiere would be -10^{-1} volt in the problem, e.g.:

1 volt (computer unit) =
$-10V_1$ volts/volts
$V_L = -1/10$ (volts/volts) x
volts (computer units)

Any errors in the scaling of the problem (either in time or amplitude) are easily detected and corrected when the problem is run on the computer. With the methods described, the errors in scaling are always less than a factor of 10. Any voltages that cause equipment to overload are scaled too high and by rebalancing appropriate loop in the computer diagram and correcting the patch panel wiring, the problem is quickly rescaled. Amplifier outputs that are less than ten volts may be detected by observation and they may also be corrected in the manner as was used to reduce overloads.

The type circuits that have been presented were rather straightforward in their development. Certain classes of circuits may not always lend themselves to an integrator for every energy storage element (inductor or capacitor).

(At this point the authors discussed "cut set and tie set theory" briefly, and then concluded:)

The advantages of this technique of circuit simulation on the analog computer are:

1. A direct relationship exists between the circuit component and the potentiometers representing them.

2. The circuit can be programmed by the circuit designer with a small amount of training in Analog techniques.

3. A minimum of mathematics is used.

4. Adjustment of time scaling is simplified.

5. Amplitude scaling is simple and direct.

6. Adjustment or modifications can be made in the problem without disturbing anything but the immediate area where the change is made.

7. Amplitude scale factors appear directly on the diagram.

Disadvantages:

1. This technique may use more computer components than classic methods.

2. Networks of one type of component (L or C) can develop into programs containing an excessive number of differentiators or algebraic loops.

Analog Techniques

It is sometimes necessary in heat-flow problems to provide for melting of the various nodes. If the material which melts cannot flow away, the circuit shown in Fig. 9 gives a method of computing the nodal temperature and the mass of liquid material at the node. This technique was developed by Mr. **M. E. White** of Lockheed Missiles and Space Division, Sunnyvale, California and used successfully in several thermal analyses. The circuit in Fig. 10 shows how to provide for the situation of melting of a surface node in which the liquid material is allowed to flow out of the system and be lost. In this case the heat capacity of the node must be changed as the mass of the node decreases.

Nomenclature

- M Mass of the node
- M_L Mass of liquid present at the node
- C_S Specific heat of solid material
- C_L Specific heat of liquid material
- $\dot{Q}$ Rate of Heat Flow into the node
- Q' Quantity of heat in the node above the amount required to bring it to the melting temperature
- θ Temperature of the node
- L Latent heat of fusion per unit mass

The operation of the circuit of Fig. 9 is as follows:

When the nodal temperature is below the melting point and increasing (i.e. $Q' = 0, \theta \leqslant \theta_M, \dot{\theta} > 0$) the temperature, θ, increases until the melting point is reached, $\theta = \theta_M$. At this time relay A throws, diverting the rate of heat flow, $\dot{Q}$, from the temperature integrator to the heat of fusion, Q', integrator. The increase of Q' immediately causes relay B to throw, breaking all input lines to the temperature integrator. This situation, $\theta = \theta_M$, $\dot{Q}' = \dot{Q}$ and $M > M_L' = \frac{Q'}{L} > 0$, prevails until $M_L = M$, at which time relay C throws and allows the temperature to increase once again, but with a new specific heat. When $\dot{Q}$ changes sign, no difficulty is encountered since the relay system is phased to operate equally well in the reverse order.

The circuit in Fig. 10 for the case of non-constant mass is simpler than the constant-mass case. The mass of the node remains constant until the melting temperature is reached, at which time both relays throw. The diode switched into the input line of the temperature integrator prevents any further increase of temperature, and the diode in the input to the mass integrator prevents any increase in the mass. When $\dot{Q}$ becomes negative, the relays throw back to their original position, but the mass of node is now less than in the original case.

The two circuits can be combined when it is necessary to treat successive layers of nodes which melt and are allowed to flow away.

FIG. 9.

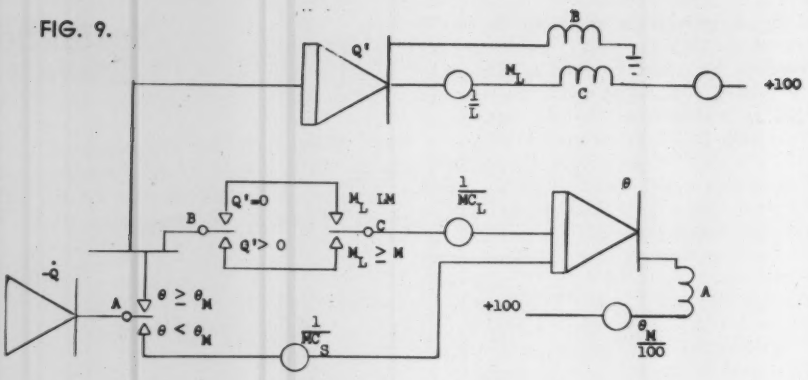
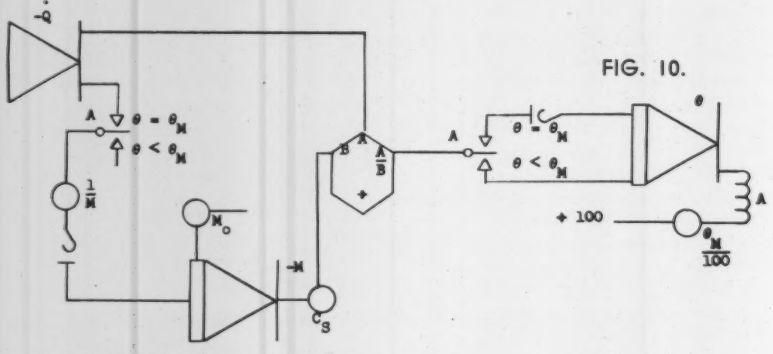


FIG. 10.



* * *

Several persons have written to your editor requesting sources for "general-purpose analog computers."

If purveyors of such equipment so request, your ED. will prepare a list of "Sources of G-P Analog Computers who read the *S/C Newsletter* and wish to be listed."

He Went Thataway!

Stan Rogers to Manager, Data Systems and Computers, Information Technology Division, General Dynamics/Electronics, San Diego.

Stan Rogers

Mart Paskman

Martin Paskman to Mauchly Associates, Ambler, Pennsylvania.

Tom Wood (two years ago!) to Computronics Inc., Fort Lee, New Jersey.

INFORMATION (Without Theory)

Because we believe in the importance of the project, we would like to pass on these excerpts from a letter forwarded to us:

"We would like to approach writers with a royalty agreement, for making courses that can be handled by correspondence methods. The subjects are to be Instrumentation, Digital Computer Programming, and related subjects."

The letter was signed by **John H. Sehlmeier,** Physics Director, TESLA Research Foundation, Box 63, Sugar House Station, Salt Lake City 6, Utah.

SCI Activities

Midwestern Simulation Council

15 May 1961; Rock Island Arsenal, Rock Island, Illinois; "Advertising Our Wares—the problem of educating working engineers and management on the capabilities of, and methods of formulating problems for, analog computer installations."

There was to be a panel discussion by **P. J. Hermann** (Dept. of Aerospace Engineering, Iowa State University, Ames, Iowa), **William B. Field** (Union Carbide Olefins Co., South Charleston, West Virginia), **Robert M. Howe** (Dept. of Aeronautical and Astronautical Engineering, University of Michigan, Ann Arbor), **A. I. Katz** (Princeton Computation Center, Electronic Associates Inc., Princeton, New Jersey), **Ralph J. King** (Caterpillar Tractor Co., Peoria, Illinois), and **L. M. Warshawsky** (Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio).

Continued on page 1097

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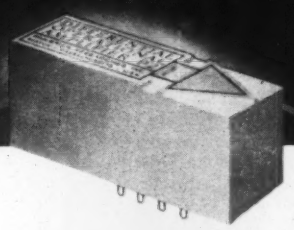

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Rocky Mountain Simulation Council

27 June 1961; Denver, Colorado, just prior to the Second Joint Automatic Control Conference. For information write **David R. Miller** of Computronics, 5310 East Pacific Place, Denver.

Southeastern Simulation Council

From **Jim Tootle,** a report on the 27 January 1961 meeting held at Atlanta, Georgia at which Georgia Institute of Technology and Scientific-Atlanta were co-hosts.

Included were abstracts of "A Low-Drift Recycling Integrator for Physiological Use" by **Andrew Spear,** and "Calculation of Microwave Antenna Radiation Patterns by the Fourier Integral Method" by **Wayne K. Rivers Jr.** (Electrical Engineering Dept., Georgia Tech), and a condensation of "The Interconnection of Remotely Located Analog Computing Equipment" (**W. C. Bennett,** Flight Controls Research Laboratory, Georgia Div., Lockheed Aircraft Corp.)

Eastern Simulation Council

From **David Jordan,** information on the 20 February meeting of the Eastern Simulation Council at IBM-Kingston, including a summary and full paper, "Model of Monitoring Performance" by **W. E. Smith** and **R. E. Sears**; the full paper "Circuit Simulation by Direct Approach" by **R. W. Boucher** and **C. T. Lecher,** (reported under **Pieces** in this issue); an abstract of "A Preliminary Study of Fixed-Bed Tubular Catalytic Reactor Dynamics on an Analog Computer" by **H. D. Yoo**; and the full paper "Computational Machine Analysis of the Transient Response of Nonlinear Circuits" by **P. A. Honkanen.** All speakers were with IBM.

Central Simulation Council

From **Tom Herndon**; a report on the 13 March 1961 meeting at Humble Oil, Baytown, Texas, including a brief description of most of the papers, and full texts of "Analog + Experimental Measurements = Practical Engineers' Answer" by **T. R. Herndon** and **Ralph Jones,** and "Some Applications of Analog Computing Elements to Data Reduction and the Development of an Accuracy-Improving Device for Multipliers"* by **T. R. Herndon.**

*Is that the title or the abstract?—Ed.

New Philbrick 6033 solid-state power supply

BALANCED OUTPUTS, COMPUTING GRADE. The 6033 is the latest addition in the distinguished line of Philbrick power supplies. It will energize at least 10 Philbrick P2 amplifiers and other transistorized electronic equipment. Like the P2, its remarkable characteristics speak for themselves. *Low internal impedance:* less than 2 milliohms. *Low noise and hum:* guaranteed less than 150 microvolts rms (0.001%). *Highly regulated outputs:* against load, less than 300 microvolts; against line, less than 200 microvolts. *Low long term drift:* typically 0.1%. *Short transient recovery time:* no load to full load, less than 1 millisecond. *Unique short circuit overload protection:* inherent in the 6033's design with no extra circuitry to deteriorate performance. *Truly low cost:* about half that of supplies with comparable performance: **$285.**

Operates from 115 volt, 50–400 cycles, providing up to 150 ma at plus AND minus 15 volts, slaved to a common reference. Conveniently packaged, cool running, and highly reliable. Available as bench model or modular plug-in. Bench model dimensions: 3½" h x 5½" w x 7½" d. Also available with 300 ma output.

Complete facts are waiting for you. Please write:

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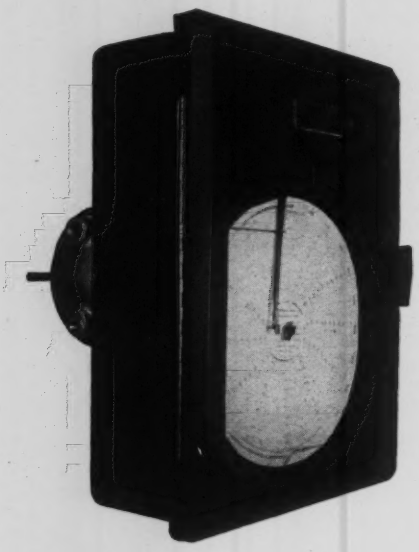
CIRCLE 97 ON READER-SERVICE CARD

THE FLOW RECORDER YOU CAN COUNT ON



Absolute dependability, under the most demanding operating environments—that's the promise and the performance of the Barton 202A flow recorder. Thoroughly proven in the gas production fields, the 202A is enjoying ever-increasing popularity in gas transmission and distribution systems. It is compact and ruggedly built, not subject to the usual frailties of such a precise instrument; it has built-in overrange protection, which allows it to maintain calibration under wide pressure fluctuations; it is immune to condensate problems, making it ideal for application in all geographical areas. A recently added bonus: the 202A can be fitted with the new Barton chart changer which allows the instrument to record continuously and unattended, for up to 16 days, using a fresh chart each day. For complete information and specifications on the 202A flow recorder, request Bulletin 202A-1.

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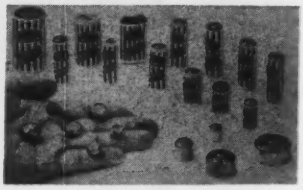
BARTON INSTRUMENT CORPORATION • MONTEREY PARK, CALIFORNIA

CIRCLE 98 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

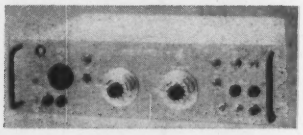
MERCURY CELLS, BATTERIES



New Mercury Cell line is a complete series of 17 basic types from which a variety of multiple-cell batteries can be designed. Mercury batteries primarily are specified when a constant voltage level is of prime importance.—*Burgess Battery Co., Freeport, Ill.*

CIRCLE 214 ON READER-SERVICE CARD

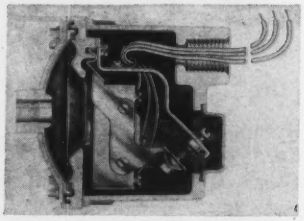
VOLTAGE AND PHASE TESTER



New NAVAPI (North American Voltage and Phase Indicator) is a precision Voltage and Phase Comparator for highly accurate measurement on in-phase and quadrature voltage components, harmonic content and noise in a-c signals over the 380-to-420-cps range. Features integral power supply, with reference voltages supplied by the system under test. In-phase error, less than 0.01%; quadrature error, less than 1.0%; in-phase reading accuracy, 0.008%; quadrature reading accuracy, 0.08%. —*Autonetics Industrial Products, Div. of North American Aviation, Inc., 3400 E. 70th St., Long Beach, Calif.*

CIRCLE 215 ON READER-SERVICE CARD

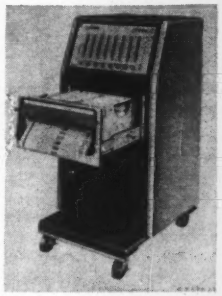
PRESSURE SWITCHES



New line of Diaphragm Pressure Switches uses erector-set technique for cost cutting mass-production methods. Accuracy is ±0.5%.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

CIRCLE 216 ON READER-SERVICE CARD

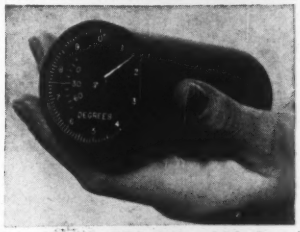
DIRECT-WRITING RECORDER FEATURES POSITION FEEDBACK ½% ACCURACY



New eight-channel direct writing system, Recorder Mark 200, produces chart records "of an accuracy and clarity never previously achieved by the direct writing method." Although designed for use with analog computers, it is equally suitable for general multichannel recording requirements. Recorder incorporates three distinct improvements over conventional d'Arsonval direct-writing techniques: (1) Position and velocity feedback using an error-sensing transducer (the proprietary Brush Metrisite) with 1/10% accuracy and infinite resolution; (2) a unique pen linkage which eliminates geometrical errors inherent in other rectilinear pen motions; and, (3) forced fluid writing, utilizing a pressurized cartridge with an average six-month capacity. The inking system ensures a high contrast, constant-width trace at all writing speeds. Features include static and dynamic accuracy of ½%, complete absence of "overshoot," error-free rectilinear presentation, and a uniform nominal trace-width of 0.010 at all writing velocities.—*Brush Instruments, Division of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.*

CIRCLE 217 ON READER-SERVICE CARD

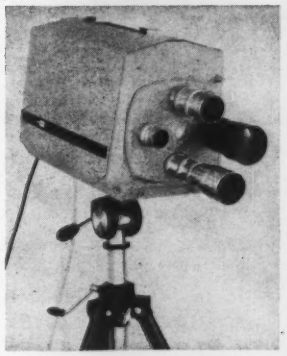
SYNCHRO ANGLE INDICATOR



New Model SBI-503 self-balancing, servo-driven Synchro Angle Indicator provides readout from 0 to 360° by combined sub-dial, calibrated in 10° intervals, and main dial and pointer which function as a 0 to 10° vernier to allow reading angular position to 0.1° accuracy, estimates within 0.025°. Unit has response speed of 60°/sec. Operates with any standard size 8 through size 15 synchro transmitter. Bulletin SFC-1.—*North Atlantic Industries, Inc., Terminal Dr., Plainview, L. I., N. Y.*

CIRCLE 218 ON READER-SERVICE CARD

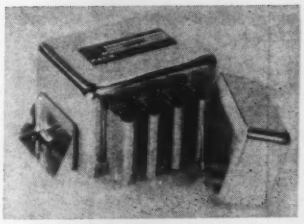
TV CAMERA CAN USE ANY HOME TV RECEIVER



New "20/20" closed-circuit television, with both camera and control unit contained in one case, can use a home TV receiver for a TV monitor to build a complete closed-circuit system. Features: 8-mc band, 650-line resolution and 2% linearity. Resolution is limited solely by the video amplifier in home receiver. An optional sync generator provides 2:1 interlace and locks the vertical sweep to the 60 cps line for optimum picture quality with a standard monitor. An alternative FINELINE sync generator may be installed to permit using the 20/20 with a FINELINE monitor to give high resolution both vertically and horizontally. Other optional features include remote drive for the 4-lens turret, lens focus automatic light control, and a variable neutral density filter to permit operations over a wide range of ambient light conditions.—*Kin-Tel, Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 12, Calif.*

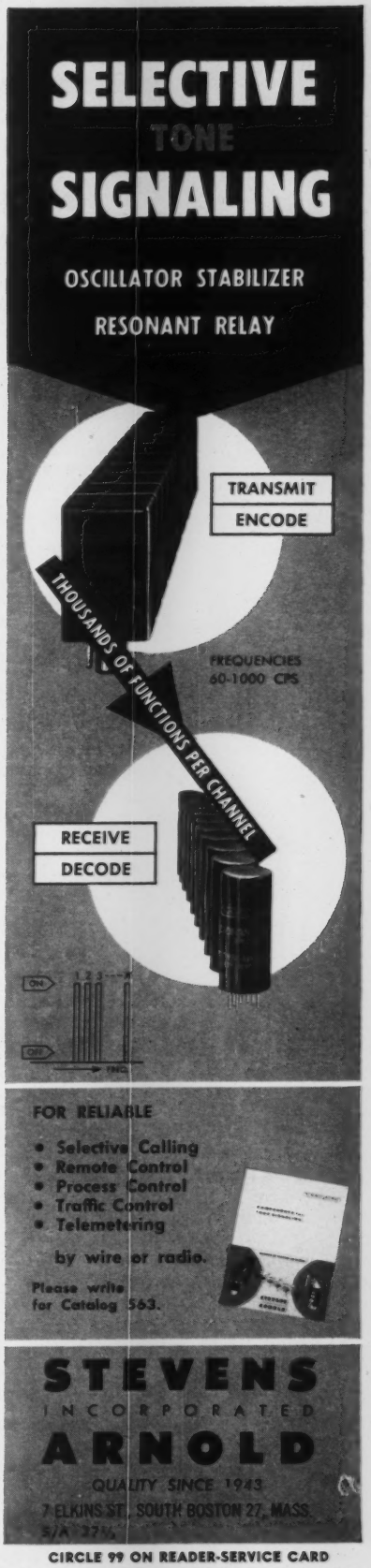
CIRCLE 219 ON READER-SERVICE CARD

THERMOCOUPLE REFERENCE



New FRJ Series miniature thermocouple reference junction for in-flight applications provides closer temperature control than ice baths, mechanical thermostats or cold junction compensators. Available for any junction temperature from 25° above ambient to 250°F, with up to 24 channels, weighs only 2 lbs.—*Pace Engineering Co., 13035 Saticoy St., No. Hollywood, Calif.*

CIRCLE 220 ON READER-SERVICE CARD



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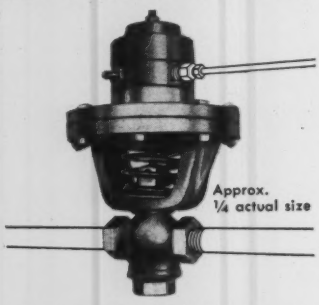
PACKAGED PNEUMATIC RELAY MONITORS CONTROL SIGNALS!



Dahl MITE 70 . . . versatile two-way, snap-acting control relay . . . can be integrally mounted on Dahl control valves or used elsewhere in control circuits on air or non-toxic gas applications.

Rugged MITE 70 offers variety of control actions at settings from 1 to 100 psig. Crisp tripping action (on either increasing or decreasing signal) vents one control circuit while locking up a second. Can be set to trigger an alarm while locking up a valve when controller signal reaches predetermined set point. For positive, reliable actuation of diaphragm motor valve operators, air cylinders, or other pneumatic control elements.

Features include safety trip-out with manual reset . . . compact size (2½" dia. x 3½" high) . . . temperature limits from −40°F to +180°F. Request Bulletin M-70 for complete details. G. W. Dahl Co., 82 Tupelo Street, Bristol, Rhode Island.

G. W. DAHL CO., INC.

SPECIALISTS IN COMPACT VALVES AND CONTROLS

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

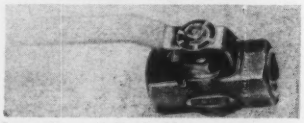
CIRCLE 101 ON READER-SERVICE CARD

PLOTTING SYSTEM

New solid-state Model 570 Plotting System produces an X-Y plot of digital data on a special recorder to checkout magnetic tape for numerically controlled machine tools, etc. Plotting is automatic, with zero positioning, scale factor adjustments, curve and symbol identification all controlled by the computer programmer. Point plotting is accomplished at 175 points/min. Reads magnetic tapes with linear density of 200 bits/in.—*California Computer Products, Inc.*, 8714 *Cleta St., Downey, Calif.*

CIRCLE 221 ON READER-SERVICE CARD

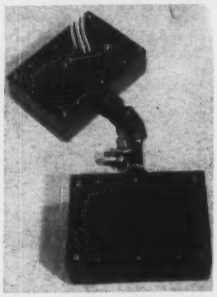
BALL VALVES



New line of Ball Valves, in bronze, steel and Type 316 s.s. is rated from vacuum to 800 psi, and from −40 to 400°F. Two-directional, they have Teflon seats for bottle-tight shutoff in air and gas service. Tapered cartridge containing the entire seating assembly can be removed easily while the valve body remains in the line.—*Crane Co.*, 300 *Park Ave., New York* 22, *N. Y.*

CIRCLE 222 ON READER-SERVICE CARD

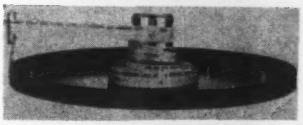
DIFF REFRACTOMETER



New Refractosyn Differential Refractometer provides a polarized electrical output indicative of the difference in refractive index of two fluids contained in separate cavities of the instrument. Either one or both fluids may be flowing or stagnant. Process control is accomplished by applying electrical output to heat-input, mixing-ratio, flow-rate, turn-off time, etc. Bulletin gives details.—*H. H. Controls Co.*, 7 *Leroy Dr., Burlington, Mass.*

CIRCLE 223 ON READER-SERVICE CARD

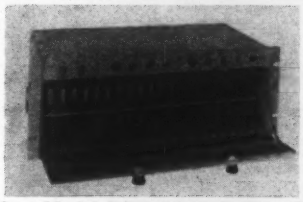
CYCLE UNWINDER



New Model 302 12-inch Cycle Unwinder is a companion for Universal Tape-Minder that automatically winds up to 1" perforated tape.—*Cycle Equipment Co., 17480 Shelburne Way, Los Gatos, Calif.*

CIRCLE 224 ON READER-SERVICE CARD

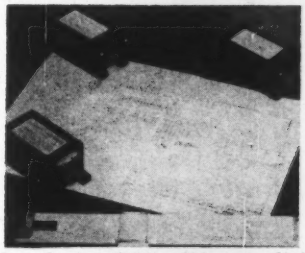
BUFFER/CONTROL EQUIPMENT



New Model RBP-72-20 Buffer/Control Unit is for driving rotary-bar printing mechanisms. Accepts inputs from magnetic tape, magnetic drum, shift registers, or any other device capable of feeding it a character at a time. Characters up to 6 bits in length are accommodated. Standard models are available with capacities of 24, 36, 72, 120, and 160 characters. —*DI/AN Controls, Inc., 40 Leon St., Boston 15, Mass.*

CIRCLE 225 ON READER-SERVICE CARD

SEQUENCE TIMING SWITCHES



New Series 7000 solid-state digital Sequence Timing Switches feature accuracy to 0.3% and initial timing periods adjustable from 0 to 30 sec. Miniaturized, they provide complete circuitry for up to 3 distinct time sequences per unit. Power requirement is 1.5 w max. from 28 v dc.—*Donner Scientific Co., Subs. Systron-Donner Corp., Concord, Calif.*

CIRCLE 226 ON READER-SERVICE CARD

VARIABLE SPEED DRIVE

New Servospeed Drive Models 1P11-20 and 1P18-20, 5-hp electronic drive systems for 440 v, 60 cps for uni-directional or bi-directional operation, are supplied with 2400 rpm base speed motor with range from 60 to 2400 rpm. Speed regulation is within 2% of set speed.—*Electro-Devices, Inc., Box 2308, Paterson 23, N. J.*

CIRCLE 227 ON READER-SERVICE CARD

Welch DENSICHRON ©

ELECTRONIC DENSITOMETER

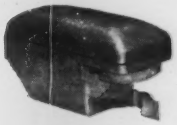
ASSURES QUICK, ACCURATE STABLE READINGS OF TRANSMISSION AND REFLECTION DENSITIES

Good Sensitivity—High Stability

SPECIAL FEATURES

Patented Magnetic Modulation
Simple to Use
Convenient Small Size—5" x 7¼" x 13"
Light in Weight—only 11½ pounds

NO. 3830A DENSICHRON AND PROBE



NO. 3832A REFLECTION HEAD

NO. 3830A. DENSICHRON WITH BLUE PROBE, including amplifier with logarithmic-scale meter, metal probe support, five different measuring apertures, a cone with ¼ inch aperture and a set of instructions. The amplifier operates on 115 volts, 60 cycle, A.C. only, except on special order .....**Each, $270.00**

NO. 3830B. WITH RED PROBE Each $295.00

NO. 3832A. REFLECTION HEAD. When coupled to the Densichron amplifier this unit becomes a convenient reflectance meter. It has a self-contained light source, filter wheel and phototube, and includes optics for both small and large spot work, a calibrated gray scale, and three Carrara working standards. 10 extra lamps .....**Each, $200.00**

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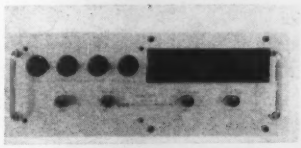
CIRCLE 102 ON READER-SERVICE CARD

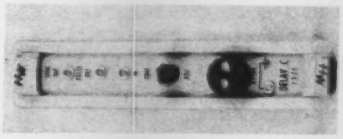
PULSE TOTALIZER



New transistorized Pulse Totalizer, Model 843, with six-digit (to 999,999) Nixie readout and four-digit preset accumulator is for flow totalizing applications using turbine flowmeters. Totalizes volume using a preset accumulator and totalizes input pulses. —*Cox Instruments Div., George L. Nankervis Co., 15300 Fullerton Ave., Detroit, Mich.*

CIRCLE 228 ON READER-SERVICE CARD

VARIABLE DELAY LOGIC MODULE



New dual-output variable delay loic module model 1321 for use in digital systems where long or adjustable delays are needed is variable from 0.1 μsec to 0.7 sec in five incremental steps and continuously variable between steps by front panel controls.—*Harvey-Wells Electronics, Inc., 14 Huron Drive, Natick, Mass.*

CIRCLE 229 ON READER-SERVICE CARD

Now available for research and development projects that demand *accurate* high-pressure regulation, Harris Model XX-87 Regulator provides unprecedented high-pressure accuracy. Its 4000/4000 lb. gauges relate fact, not fiction . . . within a new regulator capability range of 0 to 2500 lbs. per sq. in.

Oil refineries, chemical and industrial research laboratories, as well as general industry R&D have found the Model XX-87 to be the solution to high-pressure regulation problems especially for such purposes as hydrogenation, catalytic reduction, calerimetry, accelerated age-testing, and pressure testing.

The timely introduction of the Model XX-87 comes from Harris Calorific's long experience in developing and manufacturing regulators for industrial, commercial, and medical uses, metering regulators, also a complete line of welding and cutting apparatus for virtually all commercially-compressed gases. For more information regarding the XX-87 and other Harris Single- and Multi-Stage, Line, and Gaugeless Regulators, as well as complete manifold systems, call your distributor . . . or write to:

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CIRCLE 103 ON READER-SERVICE CARD

Fuses or Breakers?

QUESTION: Are there applications where the use of fused interrupters should be recommended over circuit-breakers, or vice-versa?

ANSWER: Yes. Fused interrupters are particularly suited for such light duty applications as switching and short-circuit protection of service entrances, feeders, small power and lighting transformers and load center substations where faults (as indicated by experience or nature of plant processes) are expected to be infrequent; also in most industrial plants or commercial and institutional buildings, circuits are either indoor or completely underground and feeder cables are not exposed to faults caused by lightning, wind, etc. Therefore, failures which do occur generally result in relatively serious damage and the time required to change a blown fuse is insignificant compared to the time required to make other repairs. On the other hand, circuit breakers are better suited for applications where faults are likely to occur more frequently and are of a transient nature. Also where plant processes dictate an absolute minimum down time or where complicated relaying and sequential interlocking schemes (such as power house auxiliary service or unattended pumping stations) are involved, circuit breakers are the only choice.

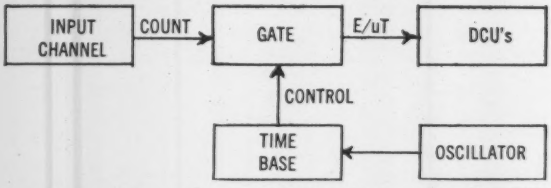
QUESTION: Is there a difference in cost between switch-gear and interrupter switches for the same application?

ANSWER: Yes. The fused interrupter is a far less complicated device and consequently will cost from 50 to 75 percent of the cost of switchgear . . . (*From Allis-Chalmers, Electrical Review, 1st Quarter,* 1961, *Allis-Chalmers, Milwaukee* 1, *Wis.*)

FOR THIS LITERATURE CIRCLE 230 ON READER-SERVICE CARD

Events-Per-Unit-Time Meter

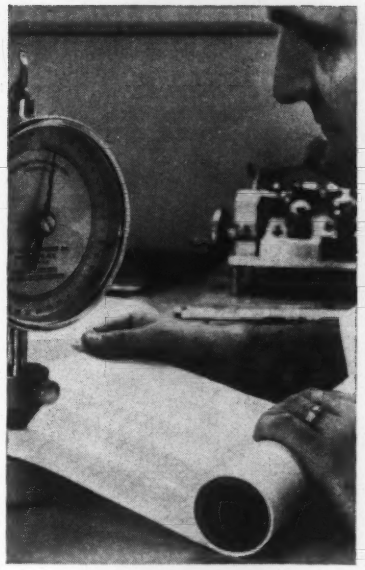
The Events-Per-Unit-Time (EPUT) Meter was developed to provide a rapid method for accurate frequency determination . . . Frequency measurements



may now be made on signals from virtually DC to 10 mc directly with EPUT meters and, with available extending equipment, to beyond 10,000 mc.

Basically the EPUT Meter consists of a high speed electronic counter equipped with an electronic gate and time base. The addition of these circuits enables the meter to count cycles of the applied signal for a precise time. Indications may be obtained in the desired units by varying the duration of the sample.—(*From new 28-page Bulletin "Digital Methods of Measuring Frequencies from dc to* 12,000 *Mc," Beckman/Berkeley Div.,* 2200 *Wright Ave., Richmond, Calif.*)

FOR THIS LITERATURE CIRCLE 231 ON READER-SERVICE CARD



A mil can matter

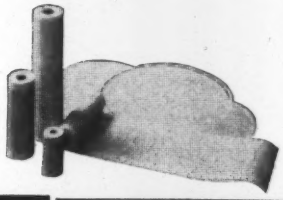
Even a *fraction* of a mil can bulk large in the thickness of a Recording Chart. That's why John Mazurowski and his thickness micrometer are so important to chart users.

Thickness of GC Recording Charts is painstakingly checked to make sure the charts you buy from us will give you the *right* answer *all* the time.

Take rigid inspection standards like these and add repeated paper and ink tests, continuous humidity control in production and storage areas, and speed of printing and delivery—you'll see why more than 5,000 chart users rely regularly on GC for quality and dependability.

More than 15,000 different chart types are stocked at GC. We also design and print charts for any special purpose you may have.

Let us send you our new complete stock list.



RECORDING CHARTS

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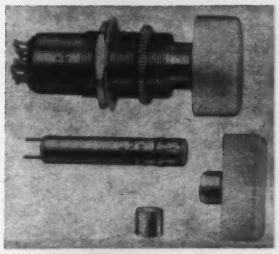
CIRCLE 104 ON READER-SERVICE CARD

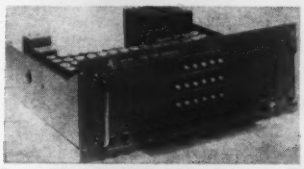
PUSHBUTTON SWITCHLITE



New 6BR Miniature Switchlite is DPDT snap-acting, designed for application where two switching functions are required, combined with an independent but logically related lamp indication.—*Eldema Corp.*, 1805 *Belcroft, El Monte, Calif.*

CIRCLE 232 ON READER-SERVICE CARD

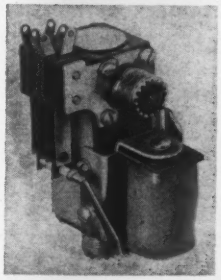
TIME CODE GENERATOR



New Model 802 M2 digital Time Code Generator produces code in the AMR 17-bit 24-hour binary format to check out ballistic missiles and space vehicles at plant development facilities. Can be switched to generate any one of three AMR code pairs (B_1, B_3,) (C_1, C_2,) (D_1, and D_3,). Supplies a 1-pps positive pulse for WWV synchronization purposes and a differentiated 1-mc square wave for direct frequency comparison. Time drift on the unit is less than 1 sec per month with a frequency stability of 3×10^{-8}/day.—*Electronic Engineering Co. of Calif.*, 1601 *E. Chestnut Ave., Santa Ana, Calif.*

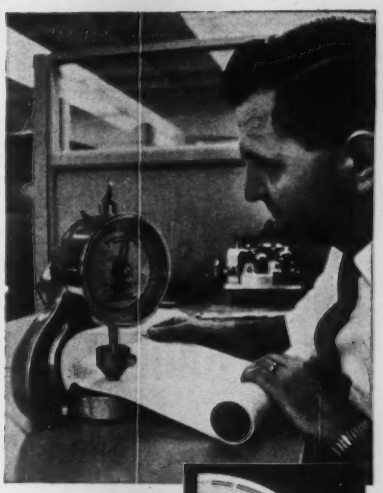
CIRCLE 233 ON READER-SERVICE CARD

COAXIAL RELAY



New CB Series Coaxial Relay is for 52-ohm coaxial lines and frequencies up to 300 mc. Ac- or dc-operated with SPDT internal contacts and up to DPDT auxiliary external contacts, its Specifications include: nominal pull-in power 2 w (d-c relay), 8-10 va (a-c relay). Contact rating: 5 amp res, 2 amp ind @ 26.5 vdc or 115 vac. —*Elgin Advance Relays, Electronics Div., Elgin National Watch Co.*, 2435 *North Naomi St., Burbank, Calif.*

CIRCLE 234 ON READER-SERVICE CARD



GC Recording Charts are accurate

New booklet helps solve SPECIAL CHART problems

If you have a unique recording or control problem which a stock chart won't fit, GC's experience will work for you.

This free booklet, "Points to Specify in Special Chart Design," offers many useful tips to consider before specifying or designing a special chart. It suggests possible types of paper, sizing of punched holes, ink colors, overprinting, grid line widths, etc.

GC service—and this booklet—can eliminate false starts and wasted time. Let us serve you. Just send this coupon.

RECORDING CHARTS

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TECHNICAL SALES CORPORATION
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GRAPHIC CONTROLS CORP.
189 Van Rensselaer St., Dept. IC
Buffalo 10, New York

Please send me your new folder "Points to Specify in Special Chart Design." No charge or obligation, of course.

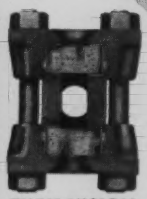
Name_____
Firm_____
Address_____
City_____ State_____

CIRCLE 105 ON READER-SERVICE CARD

Strahman

HIGH PRESSURE GAUGES

FOR CHEMICAL PLANTS AND REFINERIES



THRU VISION

REFLEX
Single or Multiple Sections

Multiple section gauges are made with a one piece body chamber. This method of construction, originated by Strahman, has become generally adopted as standard by most gauge manufacturers.

An added safety feature! Except for visibility slot, glass is completely enclosed.

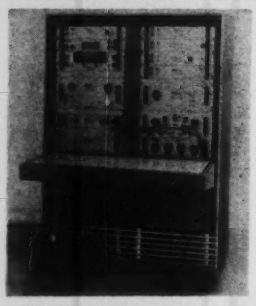
- Explosion proof illuminators
- Heated or cooled gauges
- Large Chamber Gauges
- Frost-proof extensions
- Tubular Gauges
- Gauge Cocks

P5-61B

STRAHMAN VALVES INC.
NICOLET AVE., FLORHAM PARK, N. J.

CIRCLE 106 ON READER-SERVICE CARD

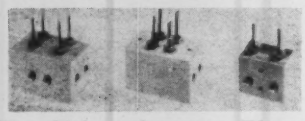
CAPACITANCE MONITORING



New Model 1001 Automatic Capacitance Monitor, a medium speed digital system for measuring capacitance, dissipation factor, and leakage current, and recording this information on high-speed punched paper tape, consists of input scanner, input preamplifiers, impedance comparator, digital voltmeter, and output control devices. Heart of the system is the transistorized impedance comparator and its associated decade unit.—*Electro Instruments, Inc.*, 8611 *Balboa Ave., San Diego* 11, *Calif.*

CIRCLE 235 ON READER-SERVICE CARD

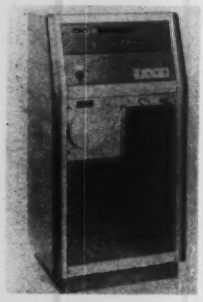
THERMAL CONDUCTIVITY



New high-performance Thermal Conductivity Detector for gas chromatography, thermal conductivity analyses, etc., includes 4-element, 2-element and micro-volume types. Bulletin Loe-6.—*Loe Engineering Co.*, 2092 *N. Lincoln Ave., Altadena, Calif.*

CIRCLE 236 ON READER-SERVICE CARD

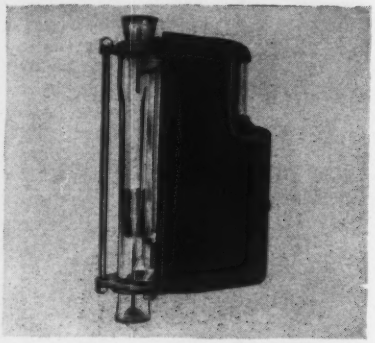
DATA ACQUISITION SYSTEM



New Single Channel Data Acquisition System DAS-22, which reads d-c output (+0.001 v to ±1000 v) from pressure, temperature, strain, depth, displacement transducers directly on to punched tape, is composed of an an/dig converter, programmer, and high speed punch. Absolute accuracy is ±0.1% of full scale ±½ least significant count. Punch output is in 1-2-4-8 binary code.—*Electronic Controls, Inc., Magee Ave., Stamford, Conn.*

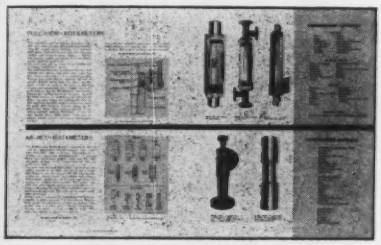
CIRCLE 237 ON READER-SERVICE CARD

METERING CORROSIVE FLUIDS? Brooks can give you an all-glass *transmitting* rotameter like this . . .



or one with a halofluorocarbon metering tube like this . . .

In fact, we can make a meter to just about any material specifications you might want. This eight-page bulletin . . .

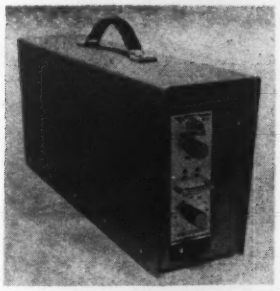


describes more than a dozen of the many materials available and gives meter construction details. Ask for Bulletin 150, and it's yours.

BROOKS INSTRUMENT COMPANY, INC.
5006 W. VINE STREET
HATFIELD • PENNSYLVANIA
BA2177

CIRCLE 107 ON READER-SERVICE CARD

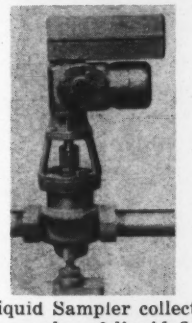
DIFFERENTIAL AMPLIFIER



New Model 516A, a wide-band Differential d-c Amplifier, features three different plug-in front ends that make the basic unit three amplifiers in one. Frequency response is 40 kc, output impedance less than 0.05 ohm, drift less than 4 μv, common mode rejection 120 db.—*Allegany Instrument Co., Div. of Textron Electronics, Inc.,* 1091 *Wills Mountain, Cumberland, Md.*

CIRCLE 238 ON READER-SERVICE CARD

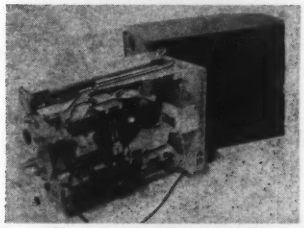
LIQUID SAMPLER



New Liquid Sampler collects representative samples of liquid flowing in pipelines regardless of pressure. Operation is manual or automatic by means of a motor and timing device. Bulletin 103.—*ARCCO Instrument Co., Inc.,* 7144 *E. Condor St., Los Angeles* 22, *Calif.*

CIRCLE 239 ON READER-SERVICE CARD

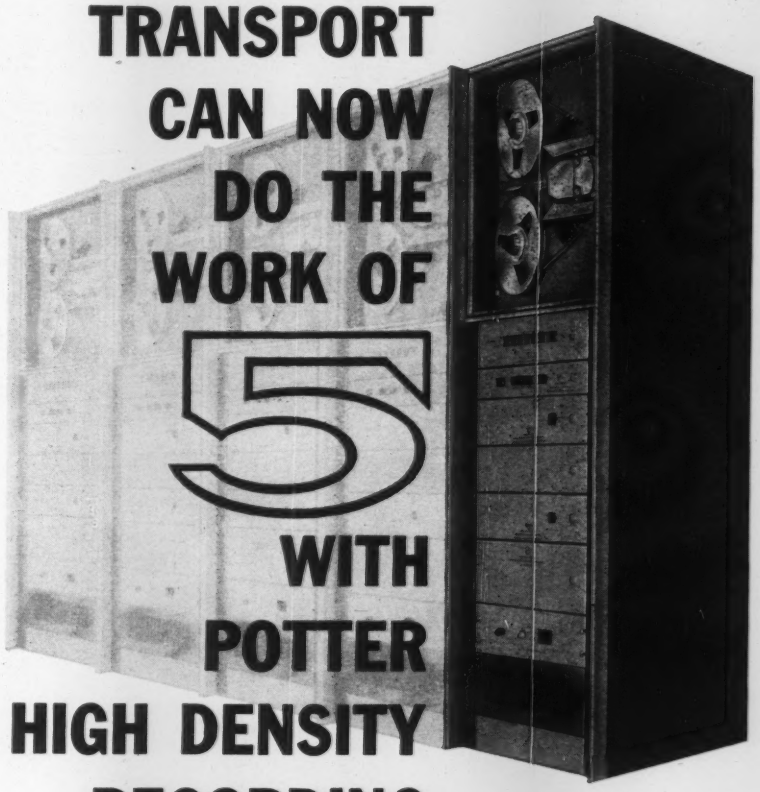
DIGITIZER ADAPTER KIT



New Kit adapts the new CP Series Decimal Digitizer to ¼-sec Minneapolis-Honeywell Brown recorders, utilizing existing mounting provisions on the recorder. Digitizers provide 1000 counts for full scale deflection of recorder pen, extremely low driving torque and cause no degradation in recorder performance.—*Coleman Electronics, Inc.,* 133 *E.* 162*nd St., Gardena, Calif.*

CIRCLE 240 ON READER-SERVICE CARD

1 TRANSPORT CAN NOW DO THE WORK OF 5 WITH POTTER HIGH DENSITY RECORDING



With the revolutionary new Potter High Density Recording System, one tape transport has the capacity of 5 or more conventional transports.

For highly reliable computer applications, Potter High Density Recording can give you data transfer rates of 360,000 alpha-numeric characters per second, at densities up to 1500 bits per inch on 1-inch tape. Sixteen parallel channels can be accommodated on one-inch tape. Because Potter has made the information channels self-clocking, no separate clock channel is needed, and multichannel data can be read out in true parallel form, despite interchannel time displacement.

In production units delivered by Potter for the BENDIX G-20 COMPUTING SYSTEM at the Carnegie Institute of Technology, this dramatic new technique makes recording so reliable that in 40 hours of continuous operation less than 2 seconds re-read time are required to recover information lost through transient error. Dropouts are fewer than 1 bit in 10 billion at 1100 alpha-numeric characters per inch. More than 20,000 passes of the tape can be made without losing information or significantly increasing the reading error rate.

Tested and proven in computer systems, Potter High Density Recording is presently available in the Potter 906II High Speed Digital Magnetic Tape Handler, and will be available in other Potter Tape Systems.

Write today for details on how High Density Recording can be applied to your data handling problem.

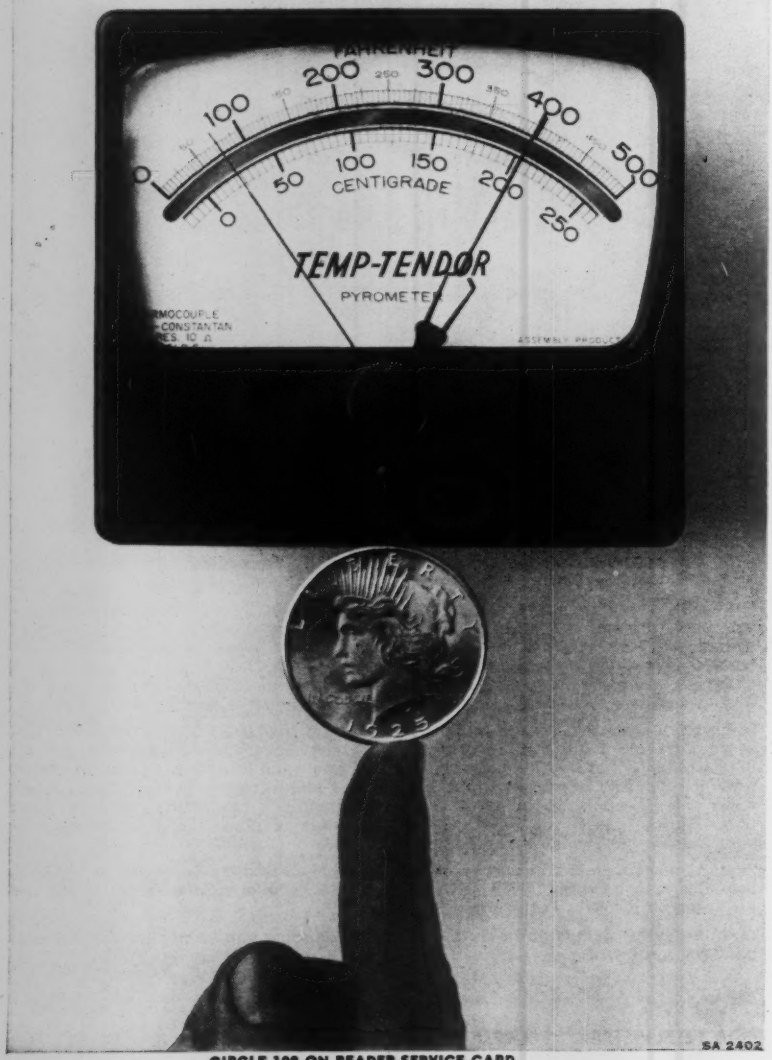
POTTER INSTRUMENT COMPANY, INC. • SUNNYSIDE BOULEVARD, PLAINVIEW, NEW YORK

CIRCLE 108 ON READER-SERVICE CARD

A NEW, SMALLER TEMP. CONTROL PRICED FOR THE OEM

Here you see, at about four-fifths actual size, A. P. I.'s new and handily compact temperature control, the Model 450 Temp-Tendor. It's a natural for "built-in" jobs. Measuring just 4" x 4¼" x 5½" overall, it's as easy to mount as a panel meter, requires no more than a meter-sized panel space. And it goes for a remarkably low OEM price. • For your money you get: a time-proportioning control capable of maintaining temperature to within ±1°F. of set-point, with built-in t/c length compensation adjustment, t/c break protection, fail-safe circuitry, instantly adjustable set-point, and a number of other features usually found only in instruments many times Temp-Tendor's modest size and cost. Available in eight standard ranges, from 0-300°F to 0-2500°F. Our Data Sheet No. 24 will give you detailed specifications. Drop us a line, and we'll put a copy in the mail.

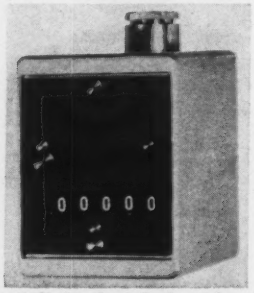
ASSEMBLY PRODUCTS INC.
CHESTERLAND 10, OHIO



SA 2402

CIRCLE 109 ON READER-SERVICE CARD

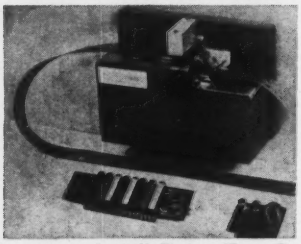
COUNTER



New 5-digit electric impulse Counter, Type TCeBZ5A, has a rectifier incorporated for d-c operation direct from a 110 vac source. Rated counting speed is 667 counts/min. Push button instantaneously resets all counting drums. Size 1-31/32" x 2¾" x 3".—*Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

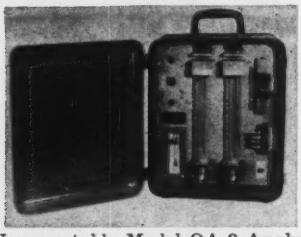
PAPER TAPE READER



New photoelectric Paper Tape Reader reads 5-, 7-, or 8-hole perforated paper tape at rates up to 20 characters/sec. Features in addition to low cost and compactness include solid-state circuitry, self-cleaning, no tape access time, positive tape indexing, up to 60% light transmissivity.—*Invac Corp., 14 Huron Dr., Natick, Mass.*

CIRCLE 242 ON READER-SERVICE CARD

DISSOLVED OXYGEN ANALYZER



New portable Model OA-3 Analyzer consists of a mixed-bed demineralizer cartridge and a packed column of pure thallium. Conductivity of the water is measured before and after passage through the thallium column, and the conductivity difference is directly related to the dissolved oxygen content in the water. Portable conductivity bridges can be used with the analyzer.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex County, N. J.*

CIRCLE 243 ON READER-SERVICE CARD

dynamic new concept of vibration testing produces

NEW PRIME ACCELEROMETER CALIBRATOR

Here's further proof of the advantages of ITT's dramatic new approach in air-suspended, lateral motion accelerometer calibrators: the ST-200 vibration exciter. Developed at the request of a major Government facility for their *prime* standard, the ST-200 will provide *double the accuracy* of other known standards.

The unique concepts of air-suspension and lateral motion that provide the performance features of the new ST-200 are also an integral part of other ITT vibration exciters for secondary and routine accelerometer calibration. These same techniques are easily adapted to other special vibration and shock testing requirements.

For complete information, applications data and performance curves, contact your ITT representative or write for Data File ICS-1469-2.

Other ITT vibration exciters for accelerometer calibration may be integrated into your present system design or can be ordered as part of complete, self-contained ITT testing systems.

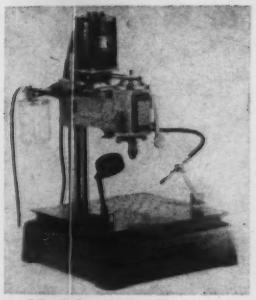
ST-110 for secondary standards

ST-115 for routine calibration

ITT **Industrial Products Division**
International Telephone and Telegraph Corporation
15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161
power conversion • instruments • closed circuit TV • avionics • mobile radio/telephone

CIRCLE 110 ON READER-SERVICE CARD

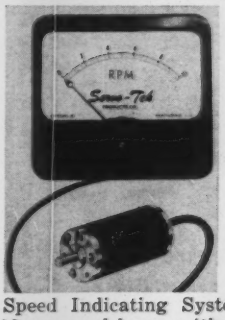
DRILL PRESS



New Model 905 Precision Drill Press with pneumatic controlled spindle is for production drilling of very small holes. Has quick spindle return when air control is released. Albrecht keyless drill chuck of 0-⅛" capacity is standard and 7500 or 10,000 rpm motors of 1/10 hp rating are available.—*Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.*

CIRCLE 244 ON READER-SERVICE CARD

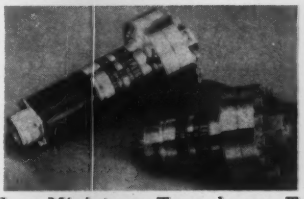
LOW-SPEED TACHOMETER



New Speed Indicating System indicates 10 rpm and lower without annoying pulsations and with an accuracy better than 2% of full scale. Consists of 4½" indicator, low-torque d-c tachometer generator, and 15-ft connecting cable. Catalog.—*Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.*

CIRCLE 245 ON READER-SERVICE CARD

MINI TRANSDUCER



New Miniature Transducer, Teleflight Model 183, is for airborne applications, measuring fluid and gas pressures up to 200 psia or psig. Accuracy is 0.25% over a wide temperature range. Measuring element is a one-piece, Ni-Span-C proving ring to which are bonded 4 precision strain gages, forming a Wheatstone Bridge. Bulletin P-61183.—*Taber Instrument Corp., 107 Goundry St., No. Tonawanda, N. Y.*

CIRCLE 246 ON READER-SERVICE CARD

New VALCOR Solenoid Valve For RADIO-ISOTOPE PROCESSING

Controls radio-active Nitric Acid, Hydrogen Peroxide, Ammonium Hydroxide, Sulphuric Acid, Sodium Hydroxide, etc.

Valcor's new solenoid valve for radio-isotope processing now handles a wide variety of radioactive corrosive chemical solutions — **even in a radiation field as high as 25 million rads!** Available in standard ¼" pipe sizes, and up to ¾" in specials. Designed for normally closed and normally open applications in all normal AC and DC voltages. Ideal for use in pressure and vacuum systems. Write today for further technical data #RV plus Valcor's free 16-page booklet telling how to select solenoid valves for over 500 corrosive media!

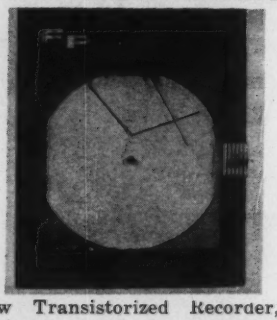
VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5366 Carnegie Avenue • Kenilworth, New Jersey • CHestnut 5-1665

CIRCLE 111 ON READER-SERVICE CARD

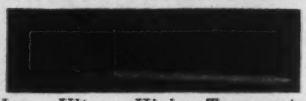
TRANSISTORIZED RECORDER



New Transistorized Recorder, a noise-free magnetic flowmeter a-c potentiometer, features positive drive action, built-in voltmeter, and direct reading range dial.—*Fischer & Porter, 826 Jacksonville Rd., Warminster, Pa.*

CIRCLE 247 ON READER-SERVICE CARD

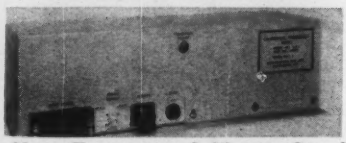
HIGH TEMP THERMOCOUPLES



New Ultra High Temperature, Series 4500 Thermocouples have range from 3000° to 6000°. Available in sizes from $\frac{1}{8}$" x 2" lg through 1" x 3' lg.—*Propulsion Development Labs., Inc., 1120 E. El Segundo Blvd., El Segundo, Calif.*

CIRCLE 248 ON READER-SERVICE CARD

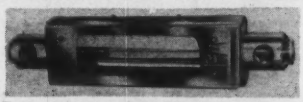
FREQUENCY STANDARD



New Frequency Calibrator-Standard, Model 14-31, has output of 100 kc and/or 1 mc and offers stabilities of 1 part 10^8 per day; and 5 parts 10^8 per week. Meets MIL-E-4970 and MIL-E-005272B.—*Northeastern Engineering, Inc., Manchester, N. H.*

CIRCLE 249 ON READER-SERVICE CARD

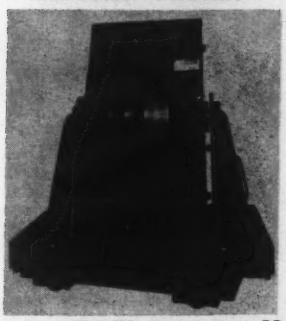
VARIABLE AREA FLOW METER



New glass-tube Varea-meter has capacities of 0.25 to 310 gpm of water, or 1.1 to 1300 scfm of air, against up to 350 psig and 400°F. Tube diameters range from ⅜" to 3" with scale lengths of 5" or 10". Standard accuracy is ±2%; custom calibration to ±1% is available. Accessories include magnetic indicators for opaque liquids, light fixtures, heaters, frost guards, and a pneumatic transmitter (with 3-15 psi air signal). Companion line of metal-tube Varea-meters will shortly be marketed.—*Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.*

CIRCLE 250 ON READER-SERVICE CARD

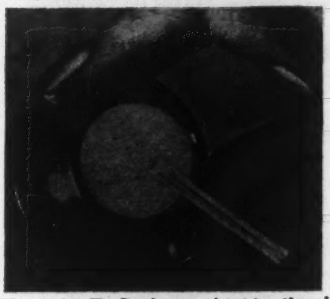
ELECTRO MAGNET



New 51½ KG Electromagnet, Model 18A-LI-Hi, has ½" gap and 1½" dia pole tips, maximum power of 200 kw (low impedance coils) and 12 kw (high impedance coils).—*Pacific Electric Motor Co., 1009—66th Ave., Oakland, Calif.*

CIRCLE 251 ON READER-SERVICE CARD

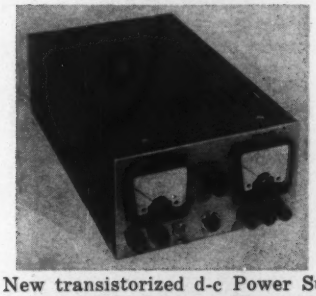
WELDABLE STRAIN GAGE



New A1-E Series weldable Strain Gage can be attached to almost all aluminum alloys with an 80 watt-second capacitor discharge welder, using RWMA electrodes in the handpiece.—*Microdot, Inc., 220 Pasadena Ave., S. Pasadena, Calif.*

CIRCLE 252 ON READER-SERVICE CARD

DC POWER SUPPLY



New transistorized d-c Power Supply, Model TR-18-3, provides 0-18 v, 0-3 amp. Addition of an external resistor converts this unit from a constant-voltage to a constant-current supply. Electrical specifications include ±0.03% load regulation, 2-mv peak-to-peak ripple, 50 μsec response time for a full load step, electronic current-limiting for momentary overloads and automatic load removal on sustained overloads. Model TR-18-3 measures 4½" x 8" x 14" and weighs 15 lb.—*NJE Corp., 20 Boright Ave., Kenilworth, N. J.*

CIRCLE 253 ON READER-SERVICE CARD

Why Varian's G-10 Potentiometer Recorder is the

PRACTICAL RECORDING CHOICE

This recorder has gained an enviable reputation over the years for performing reliably in every recording chore within its capabilities. It owes nothing to styling but the dictates of practicality and delivers performance to match — 10 to 100 mv d.c. full scale; sixteen chart speeds from 1"/hr. to 16"/min.; 1% accuracy and ¼%-of-span sensitivity; 1 or 2½ second full scale balance time; economical 5" charts with a flat platen for easy note-making. Prices — from $385.00. Fast delivery; parts and service — world-wide.

Consider the rightness of the G-10 — a potentiometer recorder that has stood the test of time, use and acceptance.

For details, write Instrument Division:

VARIAN associates

PALO ALTO 27, CALIFORNIA

NMR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

CIRCLE 112 ON READER-SERVICE CARD

Ceramo® Performance—

...Your Best Indication of Unsurpassed Quality!

"Ceramo" Performance in your most severe temperature measuring applications is your best indication of "Ceramo" Superiority! This metal sheathed, ceramic insulated thermocouple wire—used for all types of thermocouples—assures rapid response and consistent accuracy—long life with stability!

Developed by Thermo Electric Co., Inc. more than ten years ago, "Ceramo" has mastered the most difficult temperature measuring jobs; jet engines, nuclear reactors, exotic missile and rocket fuel tests, and many others, equally severe. It can be formed to practically any configuration without insulation loss and withstands extremely high pressures in measuring temperatures from minus 450°F. to plus 4000°F., and over!

Careful Manufacture

"Ceramo" is closely supervised throughout production, to assure accuracy and uniformity. In our own wire mill—the wire elements are drawn, carefully calibrated and rigidly tested for spurious emf. generation. Various inert metallic oxide insulating materials are specially processed for purity. Sheath materials are scrupulously inspected for continuity and sheath integrity. The finished "Ceramo" wires are heat-treated and annealed for proper ductility and stabilization.

Rigid Quality Controls

Quality Controls and Inspection for "Ceramo" production exceed the requirements of MIL-Q-9858, 4/9/59, "Quality Control System Requirements".

Many Types Available

"Ceramo" thermocouple wires are available in single, duplex, four and six conductor types, of standard thermocouple elements, including various Platinum-Rhodium combinations, and special Iridium-Rhodium and Tungsten-Rhenium calibrations. Wire gage sizes range from 36 to 12; outside diameters from 1/25" to 7/16". Sheath materials are available in Stainless Steels, Inconel, Aluminum, Platinum or Copper. Lengths to 30 feet are stocked—lengths to 60 feet can be supplied.

When You Must Be Sure—Specify "Ceramo" by Thermo Electric!

Write today for "Ceramo" Bulletin 12

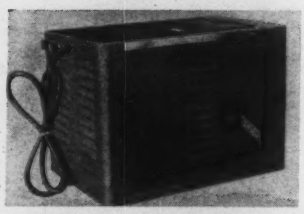
Thermo Electric

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

20 YEARS • *Temperature Measuring Systems and Components*

CIRCLE 113 ON READER-SERVICE CARD

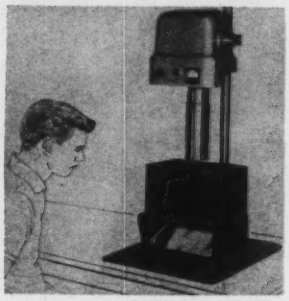
AIR DRYER



New Model 101AD refrigerated Air Dryer receives air directly from the air compressor tank at up to 150 psi pressure and cools it to a temperature slightly above freezing; then removes the condensed moisture through an automatic discharge trap. Dehumidifies 10 scfm of 100 psig air to −12°F (atmospheric).—*Zeks Industries, Inc., Westchester Pike & Providence Rd., Edgemont, Pa.*

CIRCLE 254 ON READER-SERVICE CARD

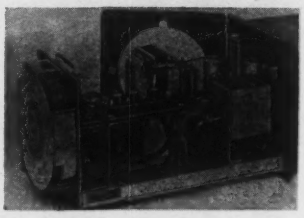
INDUSTRIAL X-RAY UNIT



New Thru-Vu industrial X-Ray Unit produces both fluoroscopic images and radiographs (films) of internal structures, weighs about 80 lb, plugs into any 115-v outlet. Dimensions are 12"x14"x26". U/L approved. Bulletin.—*Universal X-Ray Products, Inc., 1140 N. Western Ave., Chicago, Ill.*

CIRCLE 255 ON READER-SERVICE CARD

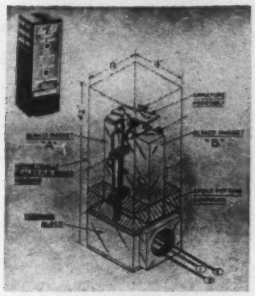
SELF-BALANCING INDICATORS



New Thermo Electronic Self-Balancing Indicators built with bridge or potentiometer circuits give more than 50 range scales and calibrations. Indicating controllers provide two (off-on) or three-position control of processes. Occupy 56 sq in of panel space. Instrument accuracy is 0.25% of full scale; sensitivity is 0.125%.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 256 ON READER-SERVICE CARD

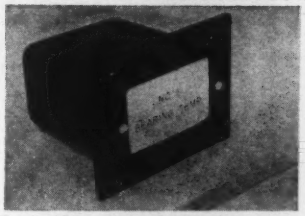
PROXIMITY SWITCH



New Proximity-type Switch performs a latching, maintained contact, or two-position switch function. Factory adjusted magnets "A" and "B" have an equal pull on the armature when it is in a neutral position. SPDT contacts are rated at 1250 w, 120 240 and 480 vac.—*General Equipment & Mfg. Co., Dept. TRP,* 116 *S. Campbell St., Louisville 6, Ky.*

CIRCLE 257 ON READER-SERVICE CARD

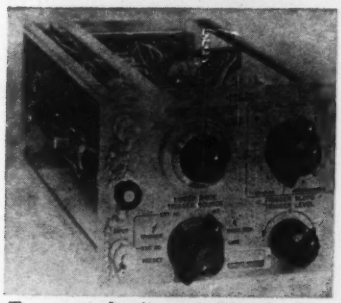
TRANSISTOR ANNUNCIATOR



New Transistorized Annunciator features a 2" x 3" indication area and operates on closing or opening of a set of remote contacts. Two models available (961A and 961B).—*Radiation Technology, Inc.,* 657 *Antone St., N. W., Atlanta* 18, *Ga.*

CIRCLE 258 ON READER-SERVICE CARD

OSCILLOSCOPE PLUG-INS



Two new horizontal Plug-in Units are the Model 166C Display Scanner and the Model 166D Sweep Delay Generator (illustrated). Model 166C provides an output to duplicate, on an X-Y recorder, any repetitive waveform appearing on the CRT Trace. Model 166D delays the main sweep of the oscilloscopes for detailed examination of a complex signal or pulse train.—*Hewlett-Packard Co.,* 1501 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 259 ON READER-SERVICE CARD

NOW, AVAILABLE FAST

FROM 12 NATIONWIDE STOCKING POINTS

TRINITY THERMOWELLS

The Industry's Most Complete Line

Only TRINITY, the industry's leading manufacturers of thermowells, has the facilities and sales volume to institute such a dynamic service designed to fill *your emergency needs* from a nationwide network of twelve stocking points.

NOW, your TRINITY representative can deliver standard thermowells *at factory prices* from Baton Rouge, Chicago, Cleveland, Houston, Los Angeles, New York City, Omaha, S. Charleston, Tulsa, and Toronto and Calgary in Canada.

NOW, you can rely on TRINITY's central inventory at Cortland, New York. Already, it includes many hundreds of ready-to-ship well types stocked in depth, and it is still growing. So even for unusual requirements, you can be sure of same-day shipment you often need.

WRITE TODAY FOR FULL DETAILS CO

TRINITY

THERMOWELL DIVISION

CIRCLE 114 ON READER-SERVICE CARD

Only Weller MAGNASTAT® Soldering Irons offer all these features!

HALF THE WEIGHT OF UNCONTROLLED IRONS

2 SOLDERING TEMPERATURES WITH MODEL TC552

2 OR 3-WIRE CORDS ARE AVAILABLE FOR ALL MODELS

HEAT CONTROL IS IN THE TIP

AUTOMATICALLY MAINTAINS CORRECT SOLDERING TEMPERATURE

GREATER HEAT EFFICIENCY WITH LOWER WATTAGE

COOLEST HANDLE

Various tip types are also available—made of copper for fast heat transfer and premium iron plated for long life. Advanced cord connection locks securely, yet permits easy replacement. Rubber shock absorber prevents iron from sliding off bench.

3 models cover all electrical and production line requirements

Model TC552 - 55 watts **$9.00 list**
Model TC602 - 60 watts **$10.00 list**
Model TC1202 - 120 watts **$11.50 list**

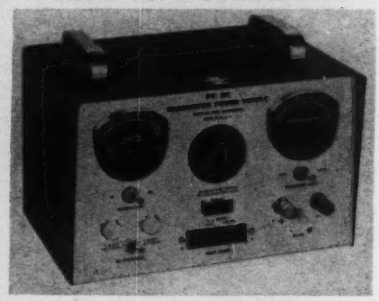
(prices shown are for irons with tip and 2-wire cord)

Send for NEW Magnastat Soldering Iron literature

WELLER ELECTRIC CORP. 601 STONE'S CROSSING RD. EASTON, PA.

CIRCLE 115 ON READER-SERVICE CARD

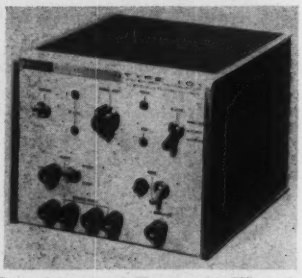
TRANSISTOR POWER SUPPLY



New multi-output DV III Transistor Power Supply features continuously variable outputs of 0-60 vdc at 1 amp, 0-30 vdc at 2 amp, or 0-115 vac at 1.2 amp. Bulletin gives specs. —*Model Rectifier Corp.*, 1675 *Utica Ave., Brooklyn* 34, *N. Y.*

CIRCLE 260 ON READER-SERVICE CARD

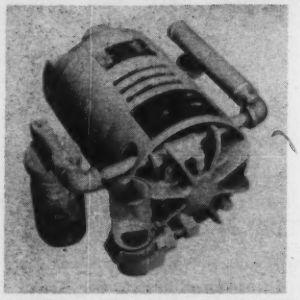
WAVEFORM TRANSLATOR



New Autograf Type 101 Waveform Translator operates with an X-Y recorder to produce an accurate, permanent, inked record of a high speed repetitive function displayed on an oscilloscope. Particularly suited for inter-connecting d-c analog simulation equipment with analog equipment operating at high frequencies, or recording the actual operating characteristics of a production item. —*F. L. Moseley Co.*, 409 *N. Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 261 ON READER-SERVICE CARD

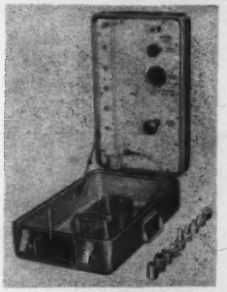
INTEGRAL AIR PUMP/MOTOR



New Model K-5 integral Air Pump and Motor providing 27" Hg vacuum continuous, 15 psi pressure, and 12 cfm volume, is powered by a ¾-hp motor and measures 22½" lg x 12" w x 7¼" h.—*Leiman Bros.*, 102 *Christie St., Newark* 5, *N. J.*

CIRCLE 262 ON READER-SERVICE CARD

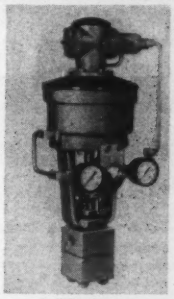
PORTABLE TEST STAND



New portable Bubble Point Test Stand provides rapid and accurate measurement of the largest opening in a filter element. Operation is by shop air at 6 to 250 psi. Each unit contains an air filter and regulator, as well as all necessary controls. Detection range of the instrument is from 13 to 120 μ.—*Aircraft Porous Media, Inc., subs. of Pall Corp.*, 30 *Sea Cliff Ave., Glen Cove, N. Y.*

CIRCLE 263 ON READER-SERVICE CARD

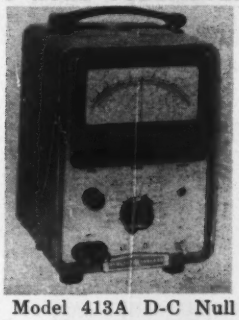
HI-PRESS VALVES



New line of High-pressure Valves, Series RB, has split-body of barstock and is suitable for 6000 psig cold working pressure. Available in steel and 347 s.s. straight-thru or angle construction, sizes ½" thru 1", with a variety of end connections. Data Sheet 103.—*Conoflow Corp.*, 2100 *Arch St., Phila.* 3, *Pa.*

CIRCLE 264 ON READER-SERVICE CARD

DC NULL VOLTMETER



New Model 413A D-C Null Voltmeter has 13 zero-centered ranges, (from 1 mv to 1000 end scale). Features include outstanding stability and resolution with 1-millivolt end scale sensitivity, a floating, high impedance input.—*Hewlett-Packard Co.*, 1501 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 265 ON READER-SERVICE CARD

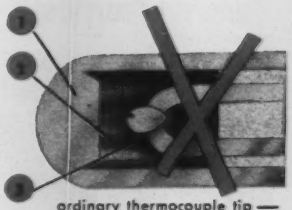
here's a
tip* on thermocouple
performance
1. In ungrounded junctions, maximum rate of response is achieved through maintenance of true cylindrical sections. Well closures are the same thickness as sheaths. (Grounded junctions also provided.)
2. Eliminates oxidation and danger of collapse by isolating the thermocouple in densely compacted insulation that completely fills the area . . . prevents vibration damage.
3. Eliminates corrosion and contamination potential arising from the use of fluxes through exclusive Conax electrical welding techniques.
* The Conax tip — highest rate of response, maximum accuracy, minimal downtime
1
2
3
Find out how little it costs to get CONAX quality

conax con-O-clad.

MINERAL-INSULATED THERMOCOUPLES

If you "X-RAYED" your thermocouples would you find these costly hazards?

1. Plug and ball welds, the mark of ordinary thermocouples mean slow response. 2. Air gaps create *three* dangers: — Oxidation that leads to thermocouple breakdown; sheath tip collapse under pressure; vibration damage to thermocouple tip. 3. Torch welding of hot junctions and well closures requires fluxes which corrode metal and contaminate insulation.



ordinary thermocouple tip — slow, inaccurate, short-lived.

TAKE A TIP — GET ALL THE FACTS ON:

CON-O-CLAD...
ask for catalog 300

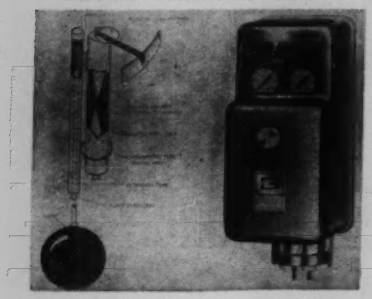
THERMOCOUPLE ASSEMBLIES...
ask for catalog 1890

ELECTRODE GLANDS...
ask for catalog 960

conax CORPORATION • 2300 WALDEN AVE., BUFFALO 25, N.Y.

CIRCLE 116 ON READER-SERVICE CARD

LEVEL TRANSMITTERS



New Line of level control instruments, including Electric and Pneumatic Transmitters, uses a new type of transducer, the magnetic position converter, that provides any or all of the additional functions of indication, alarm, and "on-off" control in a single instrument. It also transmits level measurement from a buoyant-float.—*Brooks Instrument Co., Inc., Hatfield, Pa.*

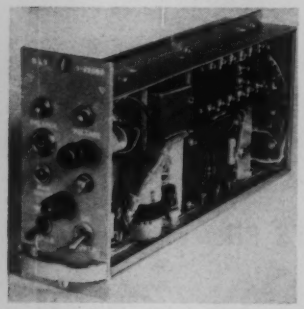
CIRCLE 266 ON READER-SERVICE CARD

INFRARED VIEWER

Newly developed portable infrared viewer weighs only 2½ lbs.—*ITT Industrial Products Division, San Fernando, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

INPUT CONDITIONER



New Model 1-220B Strain Gage and Transducer Conditioning Unit for data acquisition systems work is a single-channel module with an integral floating power supply. It may be used with 1-, 2- or 4-arm bridges, and adapts to any input wiring technique, including 8-wire bridge inputs.—*B&F Instruments, Inc., 3644 North Lawrence St., Phila. 40, Pa.*

CIRCLE 268 ON READER-SERVICE CARD

In Use Throughout the World

Daniel Flangnek Standard Meter Tubes feature factory aligned upstream tubes *guaranteed free of offsets.* Standardized tubes offer savings in ordering and installation time, and assure you of constant uniformity every time. The tubes are stocked complete with the popular Senior Orifice Fitting or the economical Simplex Plate Holder, one ¾" and two ½" couplings, and a stainless steel orifice plate bored to customer specifications. Ordering is easy. Just furnish us the following information:

(1) Size, (2) Catalog Number, (3) Plate Bore.

Send for your free copy of our Meter Tube Catalog Section "D."

DANIEL ORIFICE FITTING CO.

HOUSTON PLANT
9720 Katy Road, Houston 24, Texas

LOS ANGELES PLANT
3352 Union Pacific Ave., Los Angeles 23, Calif.

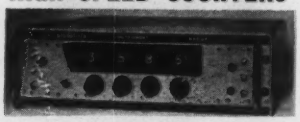
CIRCLE 117 ON READER-SERVICE CARD

0.15% SERVO VOLTMETER

New Model HV-160 DC Servo Voltmeter provides very high input impedance on all scales. Input is potentiometric (over 100 Mohm) on ranges from 3 mv to 1 v, and is 10 Mohms on ranges from 3 to 300 v.—*Houston Instrument Corp., Box 22234, Houston 27, Tex.*

CIRCLE 269 ON READER-SERVICE CARD

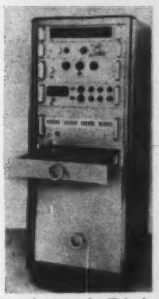
HIGH SPEED COUNTERS



New line of high-performance Electronic Counters RIG Series A offers exceptionally fast counting rates of up to one Mc. Available in 3-, 4-, 5-, and 6-place models with a preset count detection capability of up to 250 kc. —*Ridgefield Instrument Group, div. of Schlumberger Corp., Ridgefield, Conn.*

CIRCLE 270 ON READER-SERVICE CARD

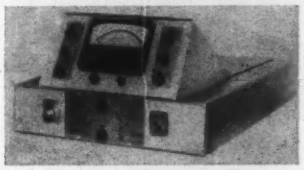
DIGITAL SYSTEM



New multichannel Digital System, Model ER-3295, displays and records multiple low-level data signals from a number of strain gages and thermocouples, on perforated tape. Consists of five major units: Model 453M Master Scanner: Model 459/N Differential Preamplifier; Model 501 Digital Voltmeter; Clary Model 703 Parallel-Entry Tape Perforator; and Model ER-3295 Format Control.—*KinTel Div., Cohu Electronics, Inc.*, 5725 *Kearney Villa Rd., Box* 623, *San Diego* 12, *Calif.*

CIRCLE 271 ON READER-SERVICE CARD

TORQUE WRENCH TESTER



New Torque Wrench Tester for power operated torque controlled tools covers range of 0-1200 in-lb and conforms to MIL-T-26498 (USAF).—Bulletin PR-500.—*Bytrex Corp.*, 50 *Hunt St., Newton* 58, *Mass.*

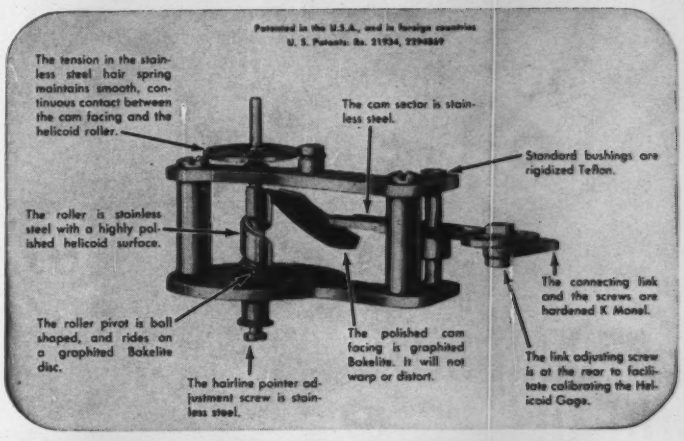
CIRCLE 272 ON READER-SERVICE CARD

CONSISTOMETER

New Consistometer is a viscometer for substances whose rheological properties cannot be investigated with one of the customary rotary, capillary, or falling-ball instruments. A controlled force is exerted on probes by means of weights which are applied either directly or by way of lever arms. The vertical displacement of the probe is then measured on a dial gage which reads directly to 0.01 mm. Bulletin available.—*Brinkmann Instruments, Inc.*, 115 *Cutter Mill Rd., Great Neck, L. I., N. Y.*

CIRCLE 273 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 118 ON READER-SERVICE CARD

RECORDING HEAD FERRITE

Kearfott's new CN-20 nickel-ferrite, specifically developed for recording head applications, is a sintered material which operates most efficiently in the 10 kc to 750 kc frequency range. CN-20 imparts superior magnetic and mechanical properties, is insensitive to mechanical stresses of potting compound during curing, is magnetically stable under temperature variation and has uniform magnetic properties. CN-20 heads have negligible deviations in inductance to temperatures as high as 160°F, using gaps of .0010 or .0015 inches.

Production quantities of complex shapes are immediately available. Dimensional tolerances of 0.0001 inch and finishes of 16 to 32 micro-inches are standard... electroplated surfaces for unusual wear resistance also available.

TYPICAL CHARACTERISTICS

Initial Permeability at 100 kc	800
Saturation Magnetization (DC) at 16 oersteds	3680 gauss
Residual Magnetization	2565 gauss
Coercive Force	0.19 oersteds
Temperature Coefficient of Initial Permeability (−20°C to +100°C)	1.0% °C
Curie Temperature	150°C
Resistivity	10^4 ohm-cm

All magnetic properties are held within a tolerance of ±15%

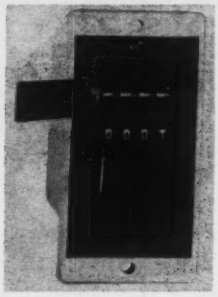
Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 119 ON READER-SERVICE CARD

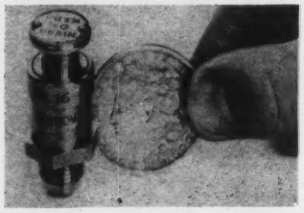
PREDETERMINING COUNTER



New 4-digit Predetermining Electric Impulse Counter, Type 2TCe-F5PE, provides a visual in-line count, and a control function, in a single compact unit. Preset by knurled wheels to any number from 1 to 9999. Incorporated rectifier premits d-c operation from 110 or 220 vac source. Rated speed is 1500 counts/min.—*Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.*

CIRCLE 274 ON READER-SERVICE CARD

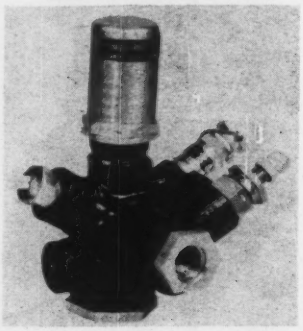
PNEUMATIC BLEED VALVE



New miniature Pneumatic Bleed Valve withstands pressures up to 14,000 psi and has an operating pressure of 6000 psig at temperatures from −65° to 160°F; releases with only 20 lb max finger pressure at 6000 psi.—*Benbow Mfg. Corp., 11920 W. Jefferson Blvd., Culver City, Calif.*

CIRCLE 275 ON READER-SERVICE CARD

PRESSURIZING VALVE



New Multifunction Pressurizing Valve combines a pressure cartridge opening valve, a pressure reducing valve, and upstream relief valve, a fill valve, and a downstream relief valve, yet fits within a 3" x 4⅞" x 5⅝" envelope. Actuation is by a low momentary current source.—*Pneu-Hydro Valve Corp., 52 Horse Hill Rd., Cedar Knolls, N. J.*

CIRCLE 276 ON READER-SERVICE CARD

ULTRASONIC LEVEL CONTROL

New Sonoswitch system consists of a miniature ultrasonic probe and an ultrasonic controller which can be remotely positioned at a convenient location. The ultrasonic probe operates magnetostrictively. The ultrasonic controller consists of a transistorized oscillator and a switching relay. Details in Bulletin.—*Powertron Ultrasonics Corp., Patterson Place, Roosevelt Field, Garden City, L. I., N. Y.*

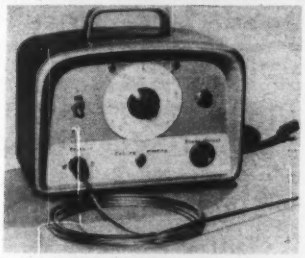
CIRCLE 277 ON READER-SERVICE CARD

FOIL STRAIN GAGES

New Dentron Foil Strain Gages are precision punched from thin metal foil, measure less than ½" x 1" x 0.002", have 120 ohms resistance, negligible hysteresis, less than 1% creep or drift. No cycling required prior to reading gage. Series 200 uses Advance metal.—*Dentronics, Inc.,* 16 *Bland Ave., Emerson, N. J.*

CIRCLE 278 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER



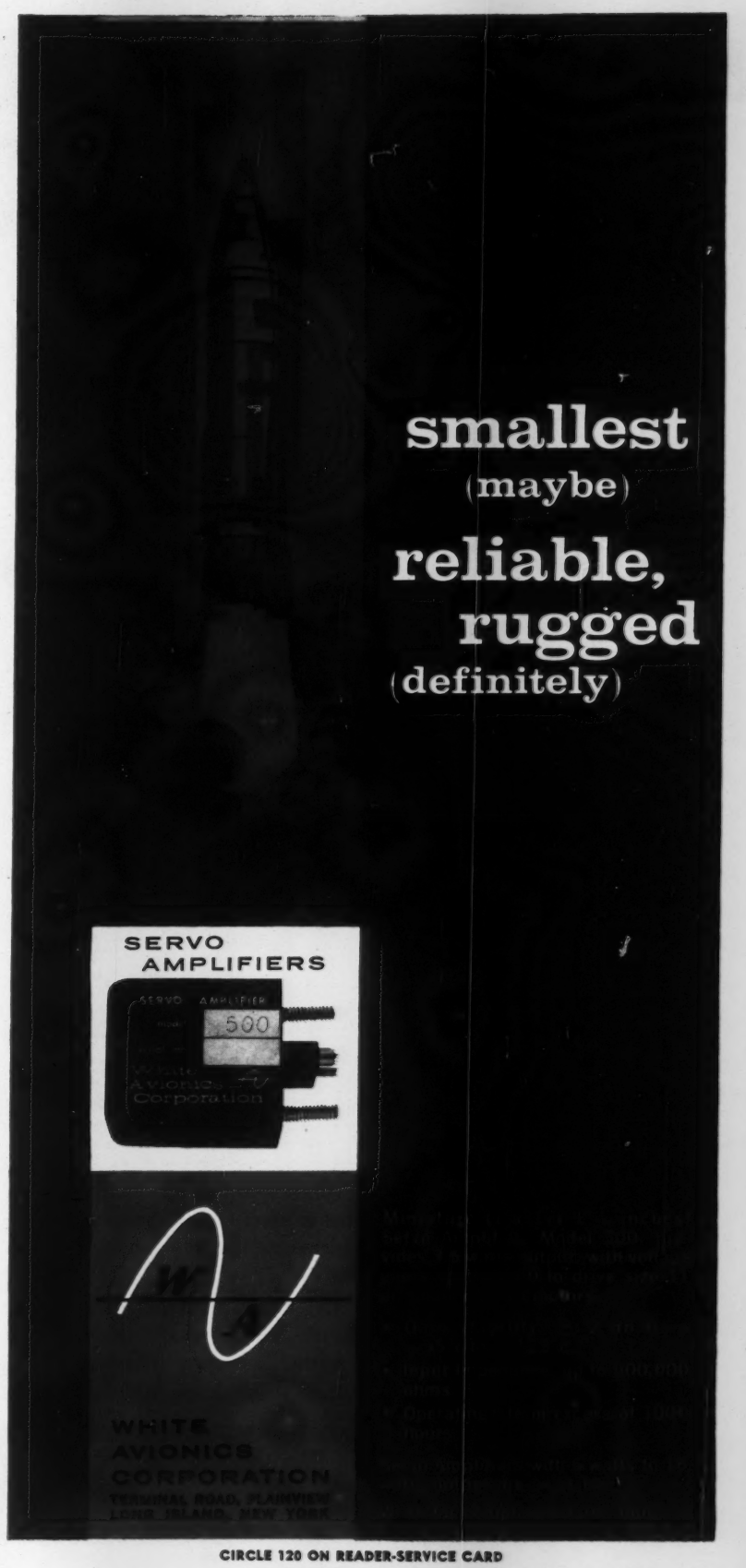
New TEM-TROL, Model N-300 temperature controller, with a sensitivity range from −100° to +300°C and accuracy to 0.5°C is only 8½" x 10" x 7". Rated load is 15 amps on both heating and cooling.—*Omtronics Mfg., Inc., Box* 1419 *Peony Park Sta., Omaha* 14, *Nebr.*

CIRCLE 279 ON READER-SERVICE CARD

RESONANT RELAYS

Tuning Fork Resonant Relays are plug-in components used at the receiving end of selective calling or remote control systems. These relays are built on the vibrating reed principle and will operate only when energized at their rated frequency. Frequencies from 150 to 1000 cps. This makes possible controlling many functions over a single wire line or radio channel.—*Stevens Arnold, Inc., 7 Elkins St., South Boston* 27, *Mass.*

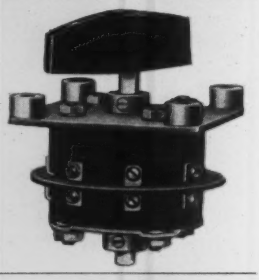
CIRCLE 280 ON READER-SERVICE CARD



CIRCLE 120 ON READER-SERVICE CARD

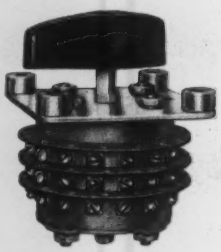
8-12-16 POSITION
ROTARY SWITCHES
for industrial and military applications

8 POSITION TYPE JR



12 POSITION TYPE JM

16 POSITION TYPE JK



Type	Sections	Positions	Poles	Contacts	Indexing	Mounting	Electrical Ratings interrupting
JR	1 to 30	2 to 8	1 to 60	non-shorting or shorting	45°	panel	10a., 125v. a-c & 28v. d-c 5a., 240v. a-c & 125v. d-c
JM	1 to 25	2 to 12	1 to 75	non-shorting or shorting	30°	panel	7..5 amp., 125 volts a-c
JK	1 to 10	2 to 16	1 to 10	non-shorting or shorting	22½°	panel	5 amp., 125 volts a-c

These three types of ESCO rotary switches are standard items designed, manufactured, and tested to meet required environmental conditions. Special switches can be assembled, from standard parts, to meet your control requirements.

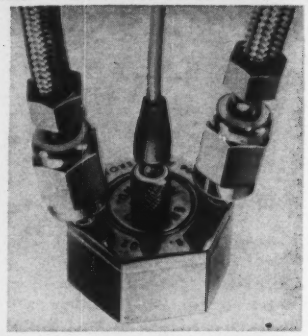
Because of the many different multi-contact assemblages possible, ESCO rotary switches can control the most complex electric circuits.

Write for catalog containing complete details.

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

CIRCLE 121 ON READER-SERVICE CARD

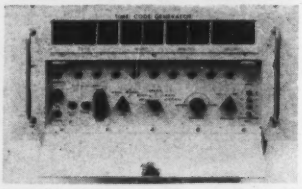
HIGH TEMP ACCELEROMETER



New liquid-cooled Model 2206 Accelerometer, a small, high-temperature shock and vibration transducer for dynamic measurements in rocket motors, combustion chambers, turbines, etc., can operate continuously on surfaces with temperatures up to 2200°F.—*Endevco Corp.*, 161 *E. California Blvd., Pasadena, Calif.*

CIRCLE 281 ON READER-SERVICE CARD

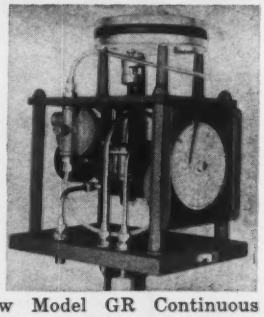
TIME CODE GENERATOR



New Model 6190 Time Code Generator generates up to three time code formats of any family of time codes such as IRIG or AMR time codes, NASA World Time Codes, or virtually any time code format. Bulletin 6190-A gives details.—*Epsco-West*, 240 *East Palais Rd., Anaheim, Calif.*

CIRCLE 282 ON READER-SERVICE CARD

CONTINUOUS GAS SAMPLER



New Model GR Continuous Gas Sampler, for the accurate determination of chemical and physical properties of a gas, over a period of seven days accumulates at a constant rate a sample to a final pressure of 300 psig from the sample source. The gas sample is gathered in a portable container for easy access to the laboratory. Bulletin 112 R-2.—*ARCCO Instrument Co., Inc.*, 7144 *East Condor St., Los Angeles* 22, *Calif.*

CIRCLE 283 ON READER-SERVICE CARD

Look to August 1961 issue of Instruments and Control Systems for expert treatment of this important control topic - - -

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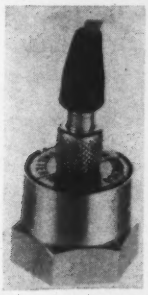
6/61

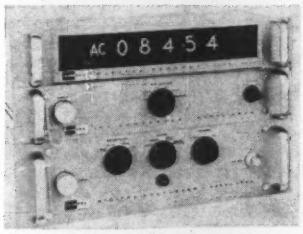
SHOCK ACCELEROMETER



New Shock Accelerometer Model 2225 accurately measures shock and impact transients because of high resonance frequency of 80 kc (nominal). Bulletin gives details.—*Endevco Corp., 161 E. California Blvd., Pasadena, Calif.*

CIRCLE 284 ON READER-SERVICE CARD

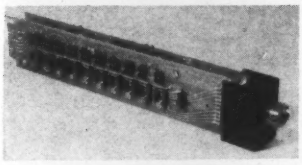
DIGITAL VOLTMETER



New 502B AC/DC Digital Voltmeter a 4-digit, programable, over-ranging unit measures positive and negative dc between 100 μv and 1000 v, and rms ac (30 cps to 10 kc) between 1 mv and 1000 v. A-C accuracy is 0.1%, d-c accuracy is 0.01% of reading. Inputs are applied to a 452B a-c converter which feeds either the original dc or a d-c equivalent of the applied a-c voltage to a 456B digital voltmeter control unit. Measured values are displayed on a 473A readout which presents four complete digits plus an over-ranging digit (0 or 1). Thus it provides the useful accuracy of a five-digit voltmeter.—*KinTel, Div. Cohu Electronics, Inc., 5725 Kearney Villa Rd., Box 623, San Diego 12, Calif.*

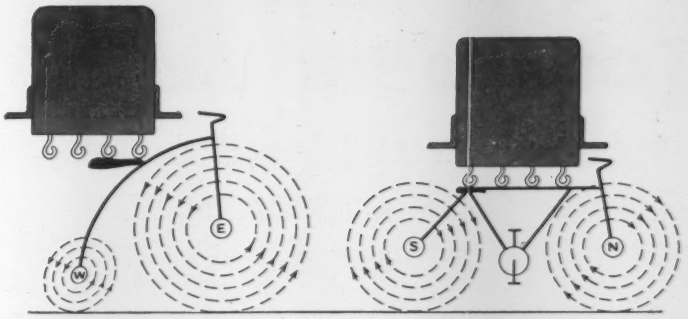
CIRCLE 285 ON READER-SERVICE CARD

VARIABLE RADIX COUNTER



New Model G-100 Transistorized Counter is for data reduction, digital clocks, or any application where counting, display, binary output drive and memory are required. Operates at rates up to 110 kc.—*Electronic Control Products, U. S. Highway 22, Box 286, Dunellen, N. J.*

CIRCLE 286 ON READER-SERVICE CARD



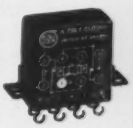
some relays are quite differential from others

If you want something to happen when a predetermined difference exists between two signals, gather 'round. Almost every* available subminiature dual coil "differential" relay we know of must have the "trip" signal applied to a specific coil and consequently the "reset" signal to the other coil. The dilemma stems from the lack of symmetry between the two flux paths or magnetic circuits of such a dual coil relay (the total pole gap changes with armature position). In a situation like this it takes more power to move the armature in one direction than the other, and when normal safety margins are added to operating power levels the disproportion becomes extreme. If you've found yourself with a relay that is this choosy about how and whether it transfers its contacts, you know you have anything but "true differential operation".

In typical and magnanimous fashion, we will now present *THE SOLUTION*, hoping that in due course it will also sell some of our relays. For true differential operation, without the pitfalls, we commend to your attention our subminiature Series 32 DPDT dual coil magnetic latching relay. The moment there's 100 milliwatts more on one coil than the other — regardless of how gradually the differential has taken place — the contacts transfer synchronously and completely. Hang up, blackout and those other monstrous contact mistakes often brought on by "sliding current" signals are neatly avoided by the design and adjustment of the "32". Its magnetic circuits and flux paths are as symmetrical as grapefruit halves, the gap remains constant no matter what the armature position, and essentially 100% cancellation occurs between coils. The 30 g to 5000 cycles vibration (operating or non-operating), 100 g shock and constant acceleration, and −65° to +125°C. operating temperature ratings all hold true for the stated 100-milliwatt sensitivity. Safety margins needn't be added just to make the specs hold true in practice.

* * *

If you've never used two collector circuits of a bistable whats-it to drive a dual coil polarized relay differentially, who knows what joys may await you? Write to Sigma today, telling us your differential troubles.



*Except ours, of course.

SIGMA

SIGMA INSTRUMENTS, INC.

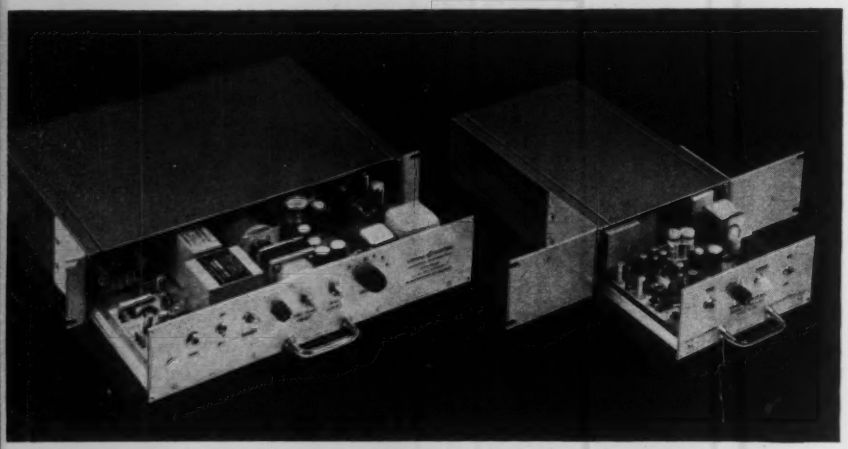
75 PEARL ST., SO. BRAINTREE 85, MASS.

CIRCLE 122 ON READER-SERVICE CARD

NEW GENERAL ELECTRIC

Transistorized Analog

FREQUENCY TELEMETERING OFFERS GREATER SPEED OF RESPONSE, INCREASED ACCURACY



Now available! General Electric's all-new Analog Frequency Telemetering System provides greatest possible *FLEXIBILITY* to meet utility load dispatching and industrial data transmission applications.

Universal design can be easily modified for varying applications resulting in system simplicity and flexibility. Manufacturing standardization assures quick delivery.

Optional plug-in audio-tone equipment permits transmission of data over voice or microwave channels where tone frequencies are required. Optional tone transmitter and receiver offer forty different tone frequencies available with conventional shift-type operation.

Completely transistorized system has *no* vacuum tubes. Telemeter transmitter, tone transmitter and receiver use only transistors in their circuitry. Telemeter receiver utilizes only diodes.

Compact System rack mounts—conserves valuable panel space.

Plug-in application adapters determine input range and output signals for both the transmitter and receiver. Plug-in filters and transformers select tone frequencies.

Combined accuracy of transmitter and receiver is ±0.5 percent of full span over these variations: ± 15°C temperature, ± 5 percent voltage change, ± 3 cycles frequency. A combined accuracy of ± 1 percent of full span is assured even when the transmitter is subjected to −20 to 55°C or ± 10 percent voltage change.

System stability—±0.5 percent of full span in six months plus ±0.1 percent of full span per each subsequent six months.

Quick response—system speed of response is rated 1 second for 99 percent of scale range—practically instantaneous. Such response is invaluable in applications involving load-frequency control wherein high-speed response is essential. In addition, there is no overshoot.

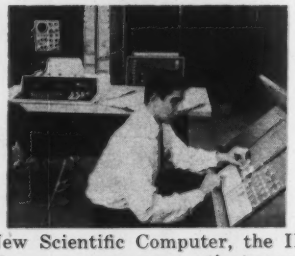
For utility telemetering in transmitting rapid fluctuation of electrical quantities such as watts, vars, volts and amperes . . . for fast positive transmission of industrial process data including quantities of pressure, temperature, liquid level, flow and many others . . . check into the cost saving advantages of G.E.'s new Analog Frequency System today. Your nearest G-E sales representative will be glad to provide you with additional information on this all-new low cost system. Be sure to ask for bulletin GEA-7163, or write direct to General Electric Company, Section 599-07, Schenectady 5, N. Y.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 123 ON READER-SERVICE CARD

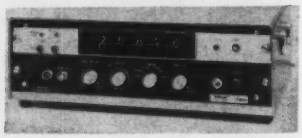
SCIENTIFIC COMPUTER



New Scientific Computer, the IBM 7072, can process magnetic tapes recorded during engineering tests despite a difference in the "languages" of the test cell and the computer. Binary data is entered directly into the computer, where it is converted into decimal form automatically and processed for immediate use. With more than two times the internal speed of the IBM 704, it has access to data stored in core storage memory in six millionths of a second. All units of the computer can be tested from a central point.—*International Business Machines Corp., Data Processing Div., 112 East Post Rd., White Plains, N. Y.*

CIRCLE 287 ON READER-SERVICE CARD

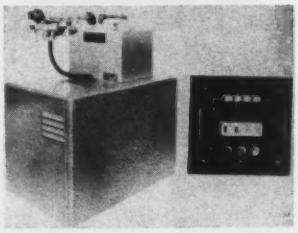
220 KC COUNTER-TIMER



New Model 725A, a new Universal Counter-Timer which accurately counts periodic or random electrical events and precisely measures frequency, period and time intervals, features in-line Nixie readout in 5 or 6 decades. Range: 0-220,000 pps; 1-220,000 cps, or 10 μsec to 10^7 sec (2,777 hours). Accuracy: 0.0001% ±count (short term).—*Erie-Pacific Div. of Erie Resistor Corp., 12932 South Webster Way, Hawthorne, Calif.*

CIRCLE 288 ON READER-SERVICE CARD

AUTOMATIC SCALE



New Dynabatch Model 816 Automatic Weighing System for liquids or slurries with a wide range of viscosities is used for completely automatic batching of one or more liquids. Available in capacities up to 10,000 lb with accuracies of 1/10 of 1% of full scale or better.—*Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*

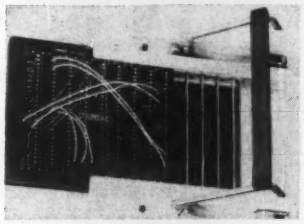
CIRCLE 289 ON READER-SERVICE CARD

STANDARD PULSE GENERATOR

New Standard jitter-free Pulse Generator, Type 404-B, emphasizes ruggedized design compatible with MIL-E-16400C for shock, vibration, humidity, and temperature. Rise and fall times are 12 nanosec. It is capable of putting 90 v into 93 ohms or 55 v into 50 ohms. Pulse widths are continuously variable between 0.05 and 105 μsec.—*Allen B. Du Mont Laboratories, Division of Fairchild Camera and Instrument Corp., 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 290 ON READER-SERVICE CARD

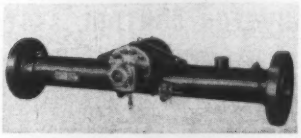
PLUGBOARD PROGRAMMING



New removable Plugboard Programming System, Model M52785, features dual hub construction, 540 contacts (which function as a 270-PST switch), and reprogramming by insertion of another pre-wired plugboard.—*SYSTEMATICS, Div. General Instrument Corp., Hawthorne, Calif.*

CIRCLE 291 ON READER-SERVICE CARD

VORTEX-VELOCITY FLOWMETER



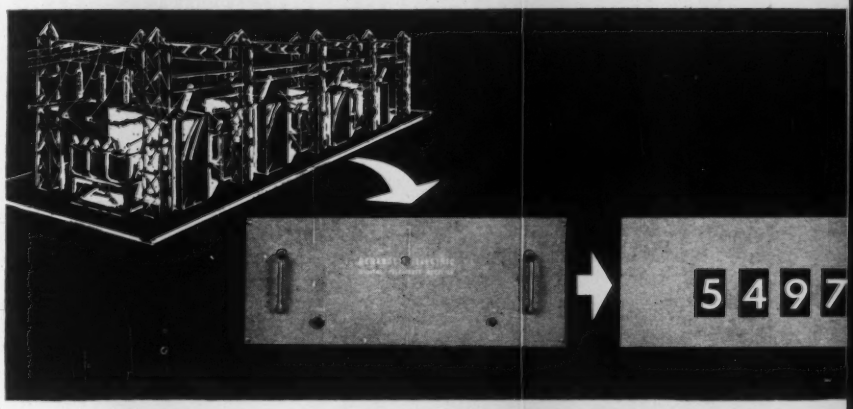
Three new models of WHIRL-FLO Flowmeters measure gas or liquid flow at high pressure. 6-inch unit, Model G6C, is for gas and Model L6C for liquids; 8-inch unit, Model G8C, is for gas, and Model L8C for liquids; and the 16-inch unit, Model G16C, is for gas, and Model L16C for liquids. Based on the vortex-velocity principle of flow measurement. Readout devices range from a single water-meter type totalizer to complex multiple-compensated integrators, as well as special transducers to feed into electronic computers and telemetering transmitters.—*Rotron Controls Corp., Woodstock, N. Y.*

CIRCLE 292 ON READER-SERVICE CARD

NEW GENERAL ELECTRIC

Digital Telemetering

SYSTEM FOR FAST,
HIGH ACCURACY
DATA TRANSMISSION



For fastest, most accurate utility load or billing information, General Electric's all-new Digital Telemetering System brings kilowatt-hour information into load dispatching office over one channel, with *100 PERCENT ACCURACY*. Offers outstanding system values . . .

Flexibility: Digital telemetering signal can be time-multiplexed with an analog telemetering signal at a preset time interval, thus providing minimum channel expense and lower operating costs. Or the digital telemetering system can be used over its own isolated channel to transmit information on command. This system will also operate over any intermediate channel equipment capable of accommodating standard analog "frequency" telemetering signals.

Accuracy: Digital receiver self-checking feature permits only the read-out of correct numbers.The receiver will cancel the readout if there has been an incorrect code or interference of the coded signal during transmission.

Speed: Digital transmission is in the form of long and short pulses at average rate of 10 cps. A six digit number can be telemetered in less than five seconds.

Design: System utilizes time-proved relays and stepping switches that require minimum maintenance. No tubes or transistors are used. Equipment is furnished in 19-inch rack, dust-proof cases with slide-out drawers.

Cost: System price is usually less than the cost of comparable integrating devices which it now obsoletes.

Various read-out devices are available depending on your requirements. These include: electric typewriter, visual digital display units and tape punch equipment if you wish to use the information in a digital computer. Digital transmitters and receivers can be provided for either 4, 6 or 8 digit numbers.

For additional information on the all-new G-E Digital Telemetering System, just call your nearest General Electric sales office, ask for a copy of bulletin GEZ-3312, or write direct to General Electric Company, Section 599-07A, Schenectady 5, N. Y. In Canada, contact Canadian General Electric Company Ltd., 940 Lansdowne Avenue, Toronto 4, Ontario.

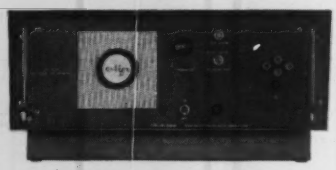
INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 124 ON READER-SERVICE CARD

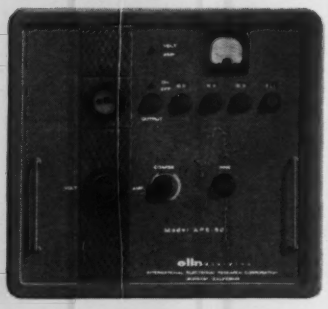
élin AC calibration instruments offer 3 versatile concepts to meet most applications!

ELIN Model VC-555 ($895.00)

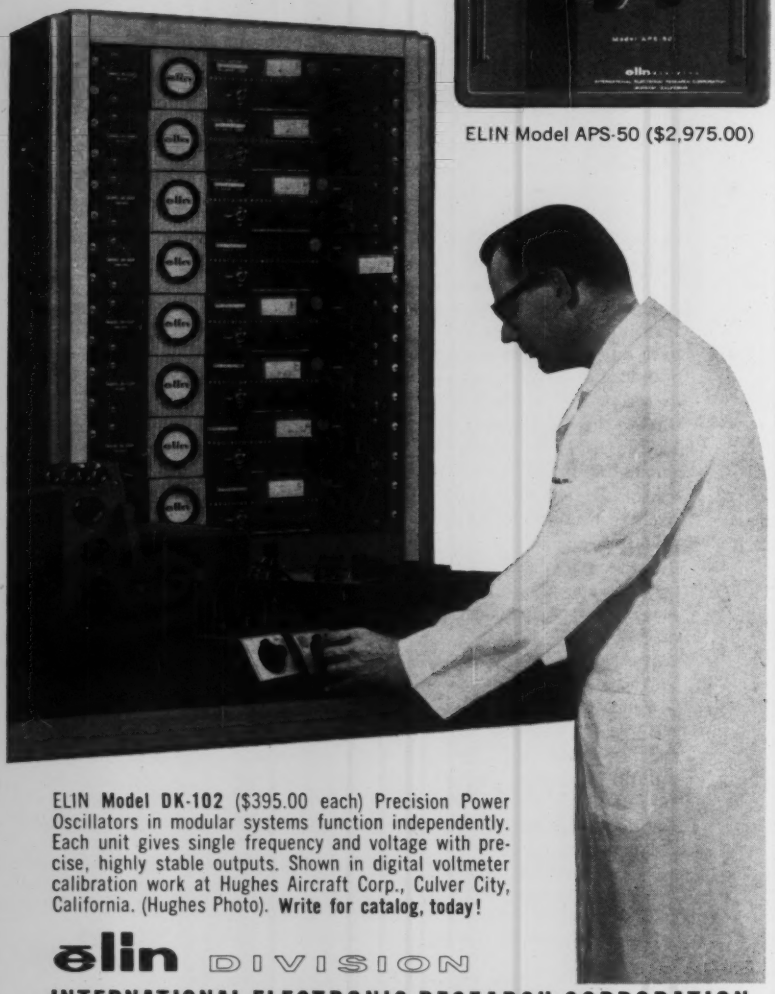


VC-555, a flexible unit, rugged, portable, for production line calibration of new-type differential voltmeters.

APS-50, used with Primary Transfer Standards requiring continuously variable frequency and voltage outputs at 50 VA.



ELIN Model APS-50 ($2,975.00)



ELIN **Model DK-102** ($395.00 each) Precision Power Oscillators in modular systems function independently. Each unit gives single frequency and voltage with precise, highly stable outputs. Shown in digital voltmeter calibration work at Hughes Aircraft Corp., Culver City, California. (Hughes Photo). **Write for catalog, today!**

élin DIVISION

INTERNATIONAL ELECTRONIC RESEARCH CORPORATION

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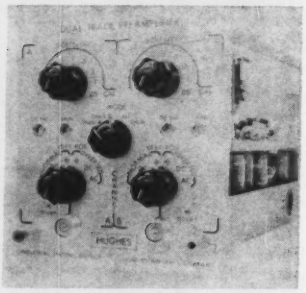
CIRCLE 125 ON READER-SERVICE CARD

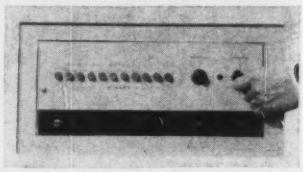
MEMO-SCOPE PREAMP



New Model 05-2 dual trace preamplifier for Memo-Scope oscilloscope model 105 (a high frequency storage oscilloscope with a writing speed of 1,000,000 in/sec) employs a blanked writing beam during switching time when operated in the chopped mode. Can provide chopped displays of both Memo-Scope channels simultaneously, alternate displays of both channels or single operation of either channel. Has a pass band of dc to 10 Mc, a chopping rate of 270 kc and a sensitivity of 0.05 volts per division.—*Hughes Aircraft Co., Industrial Systems Div., P. O. Box* 90904, *Airport Sta., Los Angeles* 45, *Calif.*

CIRCLE 293 ON READER-SERVICE CARD

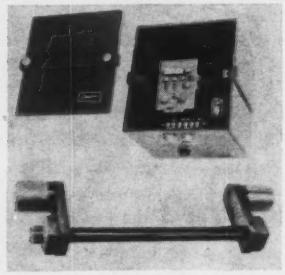
ELECTRONIC CONVERTER



New Digilog-1011, a solid-state Converter for high-speed voltage-to-digital and digital-to-voltage conversion, produces a 10-bit binary (serial or parallel) output plus polarity indication. V/d conversion rate is 5,000/sec; d/v conversion rate is 100,000/sec.—*Librascope Div., General Precision, Inc., Glendale, Calif.*

CIRCLE 294 ON READER-SERVICE CARD

CONVEYOR CONTROL SYSTEM



New electronic Control System for high-speed container and product conveyors offers fully transistorized circuits with greater reliability than mechanical and electrical controls.—*Genisco, Inc.*, 2233 *Federal Ave., Los Angeles* 64, *Calif.*

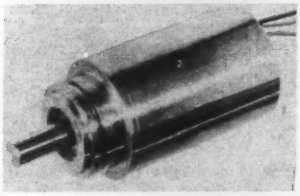
CIRCLE 295 ON READER-SERVICE CARD

DIGITAL CONVERTER

New solid-state Digital Converter, Model 4310, converts the output of potentiometric transducers into a variable frequency which can be displayed or recorded digitally on the counter or counter-printer. Operating directly into a transmitter, the converter is an inexpensive, low-power-requirement, telemetry signal generation system. For multi-channel operation, it can be connected directly to the input of the transmitter for transmission of several data channels over a single data link.—*Winsco Instruments & Controls Co*, 11789 *W. Pico Blvd., Los Angeles* 64, *Calif.*

CIRCLE 296 ON READER-SERVICE CARD

POSITION TRANSDUCER



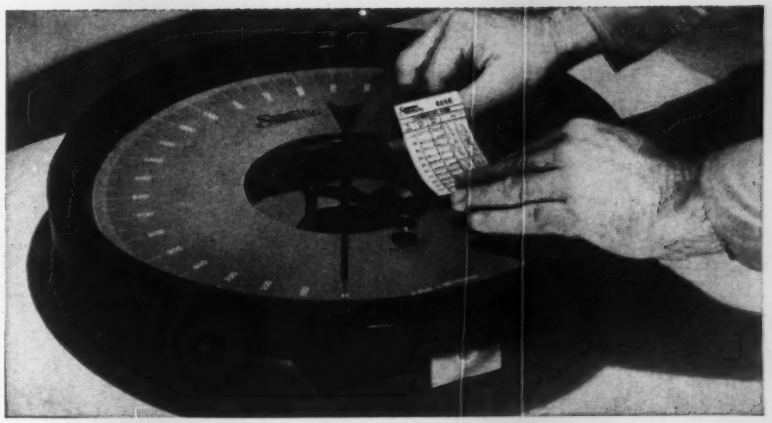
New Angular Position Transducer, GM 9060, incorporates electrical features of the linear differential transformer through the use of transformer and rotary-to-linear converter. Linearity is ±½%; sensitivity 5 v full scale; input v @ 400 cps; phase shift 3° max with an external capacitor. Available with full scale displacements from ±40° to ±10 revolutions, or more.—*Vinson Mfg. Co.*, 8044 *Woodley Ave., Van Nuys, Calif.*

CIRCLE 297 ON READER-SERVICE CARD

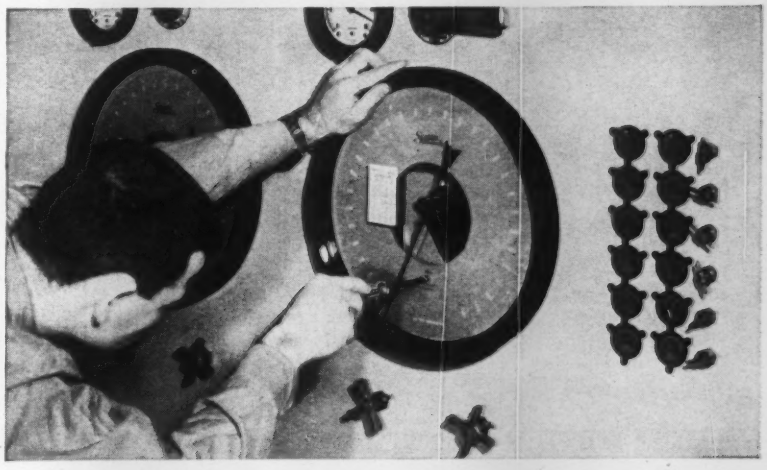
SEQUENCING SWITCH

New hermetically sealed Sequencing Switch is for rotary motion transmission (torques up to 40 in-lb) to circuit control. Used as landing gear switch on aircraft, etc. Meets MIL-E-527, MIL-I-6181, MIL-W-5026, and MIL-S-901.—*Divac Div., Acme Machine Works*, 13025 *Cerise Ave., Hawthorne, Calif.*

CIRCLE 298 ON READER-SERVICE CARD



Guaranteed accurate not only when it leaves our factory but also after field recalibration

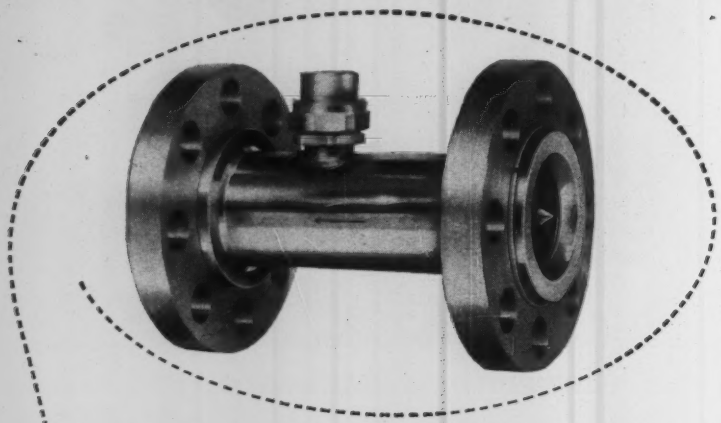


You can recalibrate Seegers precision test gauges to their original accuracy of 0.10% FS over their entire pressure range. Simple screwdriver adjustment takes only a few seconds and requires no special tools or testing equipment. Only Seegers gauges have this *true* recalibration capability. Other product superiorities include Ni-Span C and stainless steel components, eye-ease green dial with white increments linear to ±.001", and bourdon bleed and flush valve as standard equipment. *Write for a copy of our comprehensive technical bulletin.* ***Seegers Instrument Company***

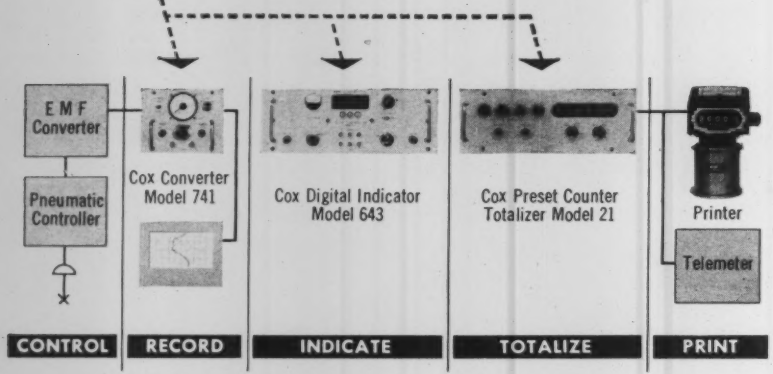
515 West Main Street, Barrington, Illinois SGS-1-200

CIRCLE 126 ON READER-SERVICE CARD

Start Right!



with **COX Turbine Flowmeters**



The most important element in any flow measurement or control system is the *primary* transducer. Start with a good signal and the final readout or control will be good. And, as many users are finding, a good way to start is with Cox Turbine Flowmeters. Here's why—

Signal output versus flowrate is extremely stable and is *±1/4% or better of actual flowrate* with rangeability as high as 65:1. Besides, Cox turbine flowmeters are rugged . . . usable with most fluids at extremes of temperature and pressure . . . and *are easily disassembled for cleaning in a matter of seconds without affecting calibration.* To insure complete system accuracy, Cox also builds auxiliary readout and control equipment.

For more information write *Cox Instruments, George L. Nankervis Company, 15300 Fullerton Avenue, Detroit 27, Michigan.*

Write for Handbook on Cox Turbine Flow Measurement and Control Systems No. 3000.

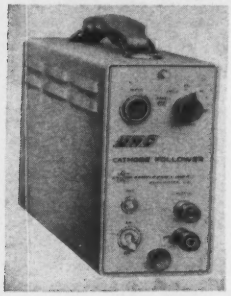
COX INSTRUMENTS

Division of **GEORGE L. NANKERVIS COMPANY**

Representatives in principal cities.

CIRCLE 127 ON READER-SERVICE CARD

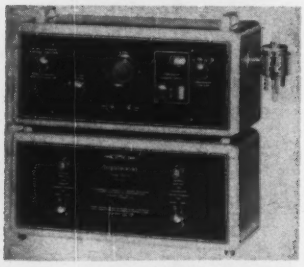
CATHODE FOLLOWER



New high-performance Cathode Follower, Model 301, has an input impedance well in excess of 1000 Mohms, a frequency range from 0.1 cps to 500 kc ±1%, a noise level of less than 20 x 10^{-6}, and gain of 0.98 with an output impedance of 300 ohms. A built-in test signal is provided.—*United Aerotronics Corp., Box 239, Burlington, N. J.*

CIRCLE 299 ON READER-SERVICE CARD

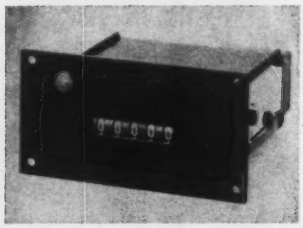
DIPOLE METER



New Dipolemeter DM 01 evaluates molecular electrical dipole moment of liquids by accurate measurement of the dielectric constant. Determines dielectric constant of liquids, pastes, and solids for non-destructive quality control, purity test, dielectric analyses, chemical investigations, etc., because of its extremely sensitive measuring range $2x10^{-5}$ for liquids.—*Kahl Scientific Instrument Corp., Box 1166, El Cajon (San Diego), Calif.*

CIRCLE 300 ON READER-SERVICE CARD

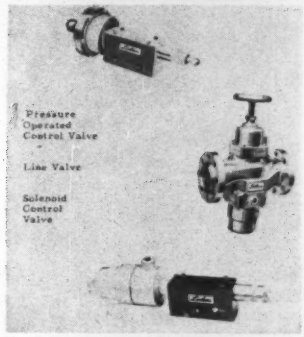
DIFF PULSE COUNTER



New Model F 160 Add/Subtract Differential Pulse Counter has two actuating coils, causing addition or subtraction on one bank of readout wheels. Differential permits simultaneous add and subtract commands without error accumulation or damage.—*Presin Co., Inc., 2014 Broadway, Santa Monica, Calif.*

CIRCLE 301 ON READER-SERVICE CARD

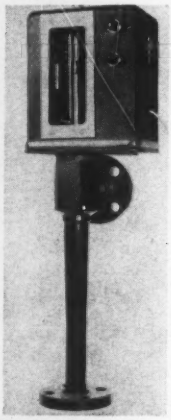
CONTROL VALVES



New Spanseal Control and Line Valves are made up of three elements: basic valve, manifold block, and operating attachments. Basic valves are available in 4-, 3-, 2-way, diverter and shuttle cycles; interchangeable attachments for low and high pressure, solenoid, manual and cam operation. Uni-directional, they are ideal for services requiring "bubble tight" shut-off of upstream pressure while venting the downstream line. Details in Bulletin 5000.—*Ledeen, Inc.*, 3350 *N. Gilman Rd., El Monte, Calif.*

CIRCLE 302 ON READER-SERVICE CARD

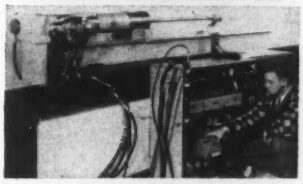
ALARM ROTAMETER



New metal-tube Alarm Rotameter, Fig. 1900-F-CDA, features a space saving design in which the visual indicating element and alarm system are included in one housing.—*Schutte and Koerting Co., Dept. M-Z, Cornwell Heights, Buck County, Pa.*

CIRCLE 303 ON READER-SERVICE CARD

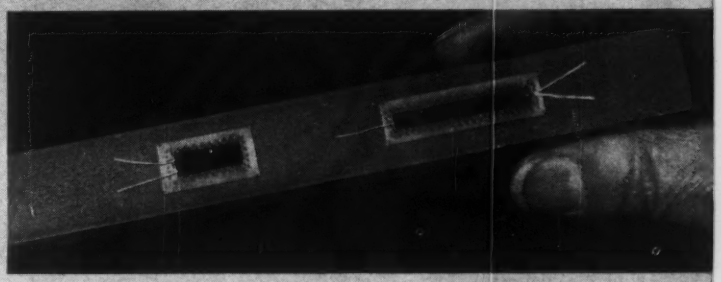
LINEAR ACCELERATOR



New Linear Accelerator consists of "Linac," Console, and Control Panel for accelerating an object up to 105 miles per hour in 7", maintaining it for a distance of 24" and decelerating to 0 in 8.5". During operation, Tayco Linear Accelerator develops from 240 to 1,000 G's as a controlled function and 760 hp on a 1½" OD shaft.—*Tayco Developments, Inc.*, 188 *Main St., North Tonawanda, N. Y.*

CIRCLE 305 ON READER-SERVICE CARD

BLH ADVANCES THE STRAIN GAGE ART WITH NEW WELDABLE, PRE-STABILIZED GAGES THAT INSTALL IN MINUTES



For the first time, strain gages that are both easily weldable and electrically stable from cryogenic through 750°F temperatures.

New BLH Weldable Strain Gages incorporate special SR-4® foil gages bonded to stainless steel shim stock .005 in. thick which can be matched to the coefficient of the test material. This new development enables gages to be closer to the test surface, improves conformity with the surface, and eliminates local buckling.

No curing needed after installation, because the gages are fully stabilized by heat treating. They offer high linearity of strain response in either tension or compression and operate in a strain range of ±0.5%.

Two types available—a phenolic-bonded Constantan foil for temperatures to 500°F, and a ceramic-bonded Nichrome V foil for temperatures to 750°F and higher. Temperature compensation is available to ±1 ppm/°F for units utilizing Constantan foil.

Wide range of applications is seen for testing nuclear reactor power loops, liquefied gas pressure vessels and systems, rocket and missile components and engines, and wind tunnel and shock chamber testing of aircraft parts.

Available locally through 16 BLH sales engineering representatives in the U.S. and Canada. For detailed information or assistance, contact the one nearest you—or us here in Waltham.

BALDWIN • LIMA • HAMILTON
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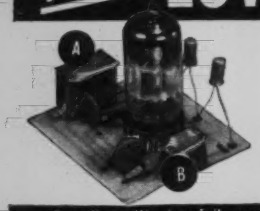
BLH — FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

CIRCLE 128 ON READER-SERVICE CARD

MINIATURIZATION PLUS LOWER COST



Thin Versatile Co-Netic® and Netic Magnetic Shielding Foils

Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

How thin Co-Netic and Netic foils lower your magnetic shielding costs:

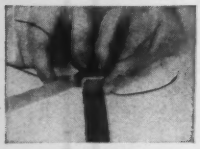
1) Weight reduction. Less shielding material is used because foils (a) are only .004" thick and (b) cut and contour easily.

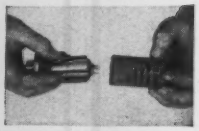
2) Odd shaped and hard-to-get-at components are readily shielded, saving valuable time, minimizing tooling costs.

These foils are non-shock sensitive, non-retentive, require no periodic annealing. When grounded, they effectively shield electrostatic and magnetic fields over a wide range of intensities. Both foils available from stock in any desired length in various widths.

Co-Netic and Netic foils are successfully solving many types of electronic circuitry magnetic shielding problems for commercial, military and laboratory applications. These foils can be your short cut in solving magnetic problems.

Cuts readily to any shape with ordinary scissors.


Wraps easily.


Inserts readily to convert existing non-shielding enclosures.

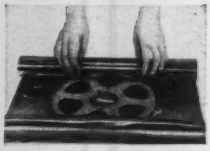
Shielding cables reduces magnetic radiation or pickup.

Wrapping tubes prevents outside magnetic interference.

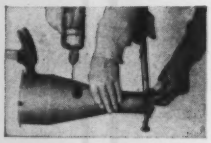
PROTECT VITAL MAGNETIC TAPES

When accidentally exposed to unpredictable magnetic fields, presto!—your valuable data is combined with confusing signals or even erased.

For complete, distortion-free protection of valuable magnetic tapes during transportation or storage. Single or multiple reel Rigid Netic Enclosures available in many convenient sizes and shapes.


Thin pliable foil wraps easily around magnetic tape, maintaining original recorded fidelity.

Rigid Netic (.014" and up in thickness) Shielded Rooms and Enclosures for safe, distortion-free storage of large quantities of recorded magnetic tapes.

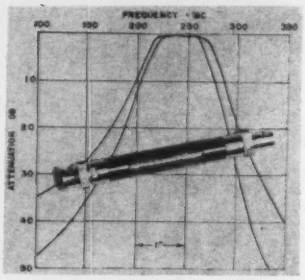

Composite photo to demonstrating that magnetic shielding qualities of Rigid Netic Alloy Material are not significantly affected by vibration, shock (including dropping or bumping) etc. Netic is non-retentive, requires no periodic annealing.

Write for further details today.

MAGNETIC SHIELD DIVISION PERFECTION MICA CO.
1322 No. Elston Avenue, Chicago 22, Illinois
ORIGINATORS OF PERMANENTLY EFFECTIVE NETIC CO-NETIC MAGNETIC SHIELDING

CIRCLE 129 ON READER-SERVICE CARD

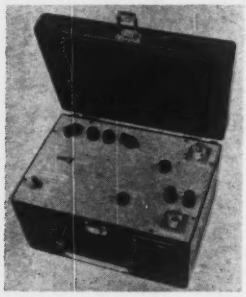
MINI BAND PASS FILTER



New miniature Band Pass Filter, Model TBP-240-40-3AB, covering the 220-260 Mc telemetering band, consists of 3 sections and has bandwidth of 40 Mc as shown by the curve. Insertion loss is less than 0.5 db and rejection at 430 Mc is over 50 db. (Other TBP types are available covering the 200-to-2000 Mc region with band pass widths of 2.5% to 20%).—*Telonic Engineering Corp., 775 Broadway, Laguna Beach, Calif.*

CIRCLE 306 ON READER-SERVICE CARD

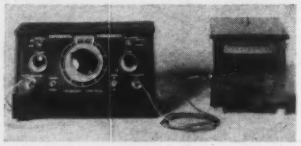
PORTABLE SYNCHRO TESTER



New Master Synchro Laboratory Tester, Model TE-2B, a portable test unit for aircraft and missile synchro-transmitter/indicator systems, embodies high-speed digital presentation. Overall accuracy is 3 minutes of angle when used either as a transmitter or receiver.—*United States Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.*

CIRCLE 307 ON READER-SERVICE CARD

DIFFERENTIAL THERMOMETER



New precision differential thermistor thermometer for measuring temperature fluctuations in colorimetry, change-of-state experiments, research reaction studies, cryoscopy, chemical and medical research, measures temperatures to 0.001°C. Thermometer reads directly in °C, from −60° to +300°C, can be used as a single point or difference-between-two-points measuring device.—*Fiske Associates, Inc., Bethel, Conn.*

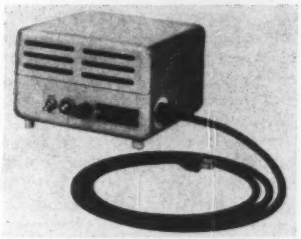
CIRCLE 308 ON READER-SERVICE CARD

LABORATORY THERMOMETER

New Model 4200 externally calibrated laboratory thermometer is accurate ±0.5% of temperature range. It can be used as a precision calibrated unit for lab measurements and as a check standard in calibrating other instrumentation such as mechanical recorders and controllers. Metal scale plates are available in standard ranges from 100° to 500°F and 100° to 250°C.—*Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark, N. J.*

CIRCLE 309 ON READER-SERVICE CARD

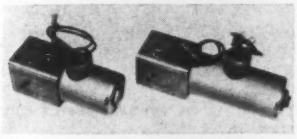
PULSE-TO-STEP CONVERTER



New Slo-Syn Translator, Type ST-150, is a pulse-to-step converter of low-level signal pulses or square waves into the correct switching sequence needed to drive a Slo-Syn Synchronous Motor at 200 discrete steps/rev. Speeds up to 225 or 400 steps per second are possible depending on the motor used. Commands originate from magnetic or punched tape or from some other type of pulse generator. Bulletin SS361.—*Superior Electric Co., Dept ST, Bristol, Conn.*

CIRCLE 310 ON READER-SERVICE CARD

DIRECTIONAL VALVES



New DIL line miniature Directional Valves for small-volume oil hydraulic systems is rated 1000 psig and has a max capacity of 2 gpm. A-c and d-c solenoids available in all standard voltages. Offered as 4-way valves in both single-solenoid and double-solenoid models.—*Vickers Incorporated, Div. of Sperry Rand Corp., Detroit 32, Mich.*

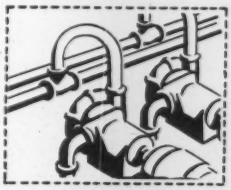
CIRCLE 311 ON READER-SERVICE CARD

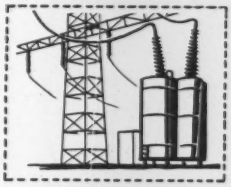
ANNOUNCING...

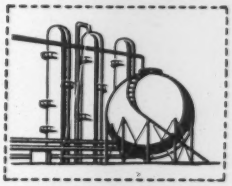
Alertra

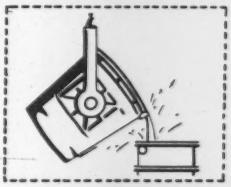
REMOTE MONITORING EQUIPMENT

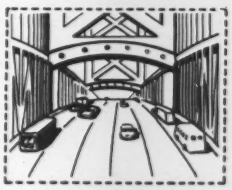
LOW COST SOLID STATE TELEMETRY



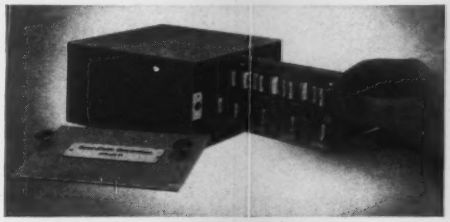








Alertra is designed for continuous remote monitoring of limits, using a single channel of any communications medium.



Alertra **costs less to Put in operation**

Single channel transmission allows use of 15 pps or voice telephone lines; teletype lines; UHF, VHF, or microwave equipment. Economical plug-in modules require no calibration or adjustment.

Alertra **costs less to Keep in operation**

Transistorized circuitry is designed for long life under continuous 24-hour operation.

Alertra **systems are Easier to expand**

Flexible, modular construction permits unlimited systems expansion. Any number of receivers can be operated from one transmitter.

C-100

WRITE FOR BULLETIN 901

CompuDyne Corporation

CONTRACTS DIVISION

400 S. WARMINSTER ROAD, HATBORO, PENNSYLVANIA

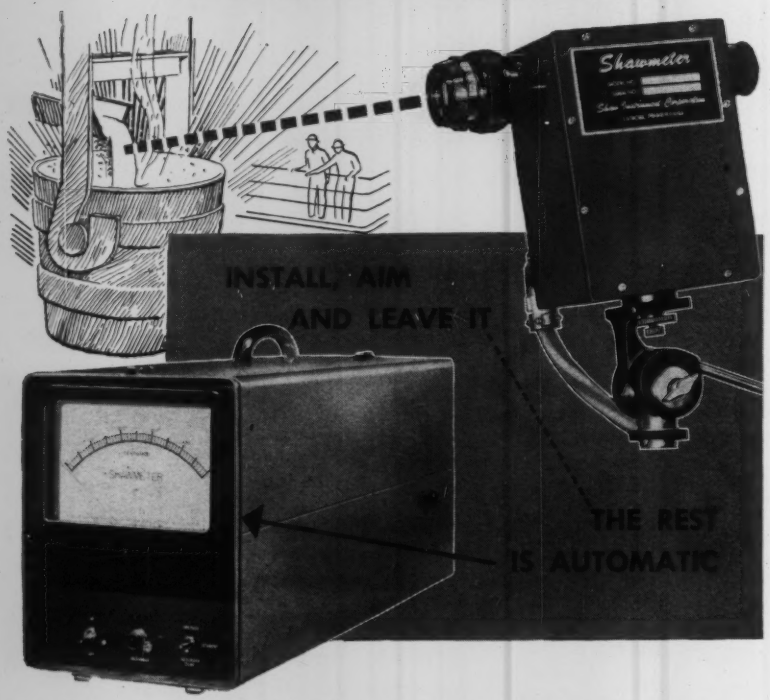
CIRCLE 130 ON READER-SERVICE CARD

Measure High Temperatures

EASILY, ACCURATELY

with the

SHAWMETER®



The SHAWMETER is an automatic, direct-reading, two-color pyrometer for indicating, recording or controlling temperatures up to 6500°F.

Measures the temperature of flowing metal, or of moving or stationary objects. No emissivity correction needed. Temperatures may be measured at a considerable distance from the object.

Accurate, sensitive, rugged. Write for complete details.

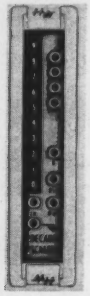
SHAW INSTRUMENT CORPORATION

CERAMIC-METAL SEALS • NUCLEAR and ELECTRONIC INSTRUMENTATION

P. O. Box L-46 Latrobe, Pennsylvania

CIRCLE 131 ON READER-SERVICE CARD

10-MC DECADE SCALER



New 10-Mc Decade Scaler is a count-to-ten device that utilizes 8-4-2-1 binary code to count random serial pulses at any rate up to 10 Mc. Count is displayed on panel in neon-lighted decimal digits. Output can drive printer. Compatible with the entire DATA BLOC family of high-speed digital building block modules.—*Harvey-Wells Electronics, Inc.*, 14 *Huron Dr., Natick, Mass.*

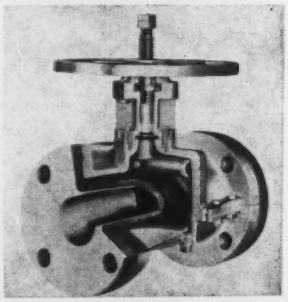
CIRCLE 312 ON READER-SERVICE CARD

DUAL POWER SUPPLY

New compound-regulated Dual Power Supply, Model R-500, consists of two separate regulated supplies on one chassis, with a common reference, which provide ±300 vdc, each rated at 500 ma. Specification sheet gives further information.—*George A. Philbrick Researches, Inc.*, 285 *Columbus Ave., Boston* 16, *Mass.*

CIRCLE 313 ON READER-SERVICE CARD

PINCH VALVE



New Pinch Valve, Series L, features complete opening even for operating pressures below 10 psig. Available in sizes from ¼" to 14" ID for a maximum operating pressure of 400 psig. Furnished for hand, air, electrical or electrohydraulic operation.—*RKL Controls, Inc., Haines-port, N. J.*

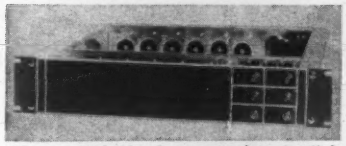
CIRCLE 314 ON READER-SERVICE CARD

CONTROL VALVES

New Series 20000 Single Seat Valves, sizes 1"-10", feature soft-seat plugs to provide tight shutoff for static pressures and pressure drops to 500 psi. Closed, plugs withstand differential pressures in excess of 1,000 psi.—*Mason-Neilan, Div. Worthington Corp.*, 25 *Nahatan St., Norwood, Mass.*

CIRCLE 315 ON READER-SERVICE CARD

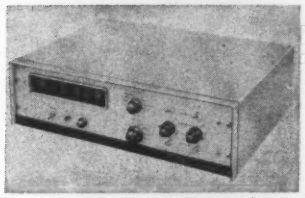
ANALOG COMPUTER MODULE



New stabilized operational "six-pack," stored program Analog Computer Building Block accommodates 6 pairs of plug-in amplifiers to provide six channels of high-gain, drift-stabilized analog computation. Programming for computer control or process and system simulation is accomplished internally by permanent wiring of circuit components on phenolic terminal board.—*Embree Electronics Corp., 993 Farmington Ave., West Hartford 7, Conn.*

CIRCLE 316 ON READER-SERVICE CARD

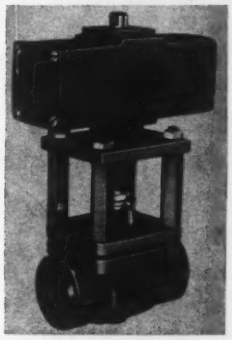
COUNTING SYSTEM



New Model 851 solid-state Megacycle Frequency-Time Digimeter consists of two identical 1-2-4-8 BCD counting trains, combined with two identical input amplifier channels and switching unit. Gated time base counter divider provides burst or damped train measurements, extends accuracy of period measurements by continuous decimal selection of period groups.—*Electronic Counters Inc., 155 Eileen Way, Syosset, L. I., N. Y.*

CIRCLE 317 ON READER-SERVICE CARD

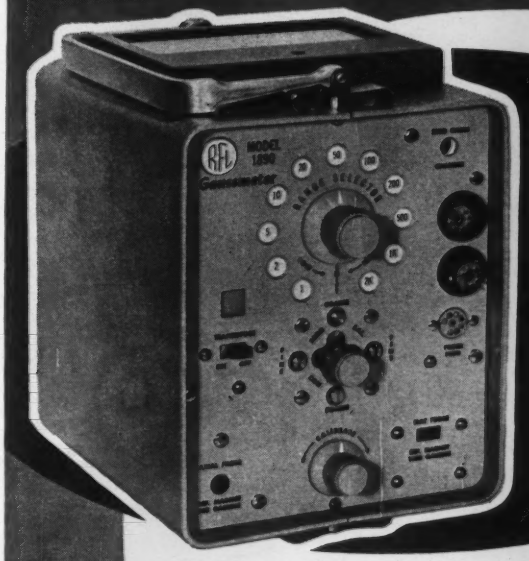
BALL VALVE ACTUATORS



New line of vertically mounted pneumatic actuators for valves from ¼" through 8" sizes is totally enclosed. Horizontally mounted cylinder-and-level type operators are available for all valves from 3" through 8" sizes. Available with valves or separately for installation on valves in service. Catalog 1200.—*Hills McCanna Co., 4600 West Touhy Ave., Chicago 46, Ill.*

CIRCLE 318 ON READER-SERVICE CARD

Analyze Magnetic Circuits



Versatile, Transistorized Instrument Measures DC to 400 cps Fields Directly

RFL Model 1890

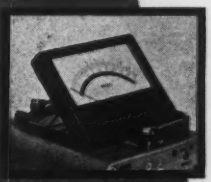
Gaussmeter

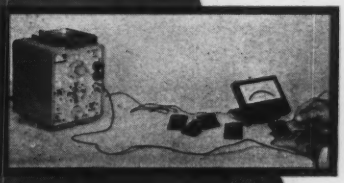
measures flux densities from 0.1 to 20,000 gausses with .01-gauss resolution

Sensitive enough to register half-scale deflection for the earth's magnetic field, the Model 1890 provides a selection of 14 overlapping ranges from 1 gauss full-scale to 20K gausses. Accuracy over all ranges, using standard reference magnet, is better than 3%, with repeatability of meter readings better than 0.5%.

Temperature stable, InAs flat and axial probes are encapsulated in glass reinforced epoxy for durability and safe use around exposed electrical circuits.

The indicating meter is calibrated in gausses, has mirror scale, knife edge pointer and can be adjusted to four positions for most comfortable reading.





Meter has flexible leads, can be removed from cabinet and placed next to magnet structure being measured for most accurate reading. Jacks for external recorder output (1 ma. into 1500 ohm max.) and oscilloscope (2 volts max.) are also provided. Choice of plug-in AC supply or battery pack for portable or field use.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

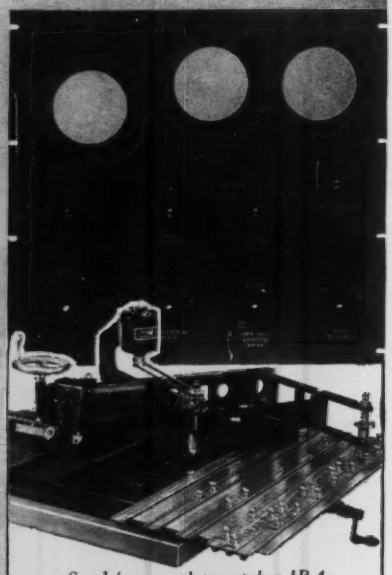
For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

CIRCLE 132 ON READER-SERVICE CARD

any size panels

engraved in your own plant



Engrave 1-inch nameplates or 6-foot panels by unskilled labor.

Spindle covers 18¼" x 6" in one set-up — more than any other machine of its kind.

Bench type model I-R—$685.

Send for complete catalog JR-4 illustrating other models from $325 up

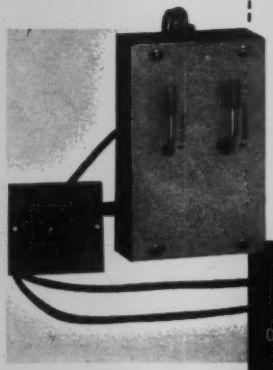
new hermes ENGRAVING MACHINE CORP.

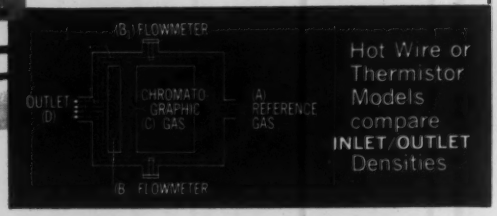
154 WEST 14th STREET, NEW YORK 11, N. Y. IN CANADA: 359 St. James Street West, Montreal, P. Q.

CIRCLE 133 ON READER-SERVICE CARD

GOW-MAC offers two new GAS DENSITY DETECTORS

–for Gas Analysis and Vapor Phase Chromatography





Hot Wire or Thermistor Models compare INLET/OUTLET Densities

Simply .....
Quickly.....
Accurately..
Reliably ....

New GOW-MAC Gas Density Detectors are available with either hot wire or thermistor detector elements, blocks of brass or stainless steel. Call or write for complete information and specifications, today! Request Gow-Mac Bulletin GADE 461; please address inquiries to Dept. IA

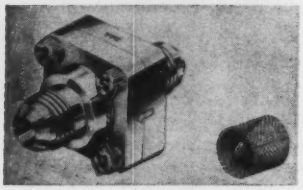
GOW-MAC INSTRUMENT COMPANY

100 KINGS ROAD, MADISON, N. J., U. S. A. • Telephone: FRontier 7-3450

GAS ANALYSIS INSTRUMENTS SINCE 1935

CIRCLE 134 ON READER-SERVICE CARD

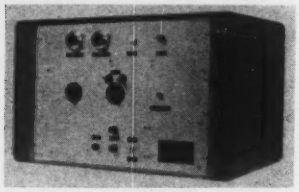
FILTER ASSEMBLY



New 1⅛" x 1⅛" x 2" Filter Assembly for fluid line systems has been in service with gases to 2250 psi, withstands temps from −350° to 500°F. Fits ¼" and ⅜" tube sizes. Cylindrical, wire-mesh element provides 1.2-in² filter surface; approx ½ is open flow area.—*Dumont Engineering Corp.*, 1401 *Freeman Ave., Long Beach, Calif.*

CIRCLE 319 ON READER-SERVICE CARD

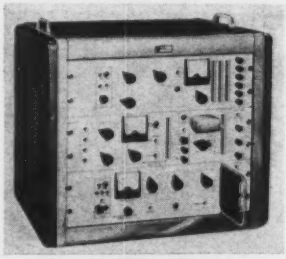
RECOVERY TIME TESTER



New Diode Recovery Time Tester measures in accordance with JAN 256. Output is in the form of an analog voltage which can be converted to digital form for direct recording of recovery current. Contains integral forward current bias supply and reverse voltage supply. Specifications in Bulletin 60-1.—*Contronics, Inc.*, 37 *Leon St., Boston, Mass.*

CIRCLE 320 ON READER-SERVICE CARD

DIGITAL MODULE TESTERS



Three new test units offer complete check of all standard T-PACs.—static flip-flop, thyratron driver, synchronous generator, serial memory packages, core memory packages, etc.—*Computer Control Co., Inc.*, 983 *Concord St., Framingham, Mass.*

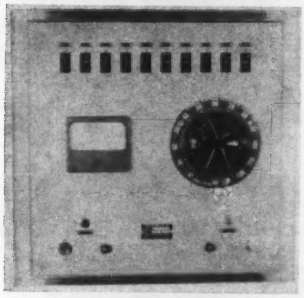
CIRCLE 321 ON READER-SERVICE CARD

TAPERED ZIPPERTUBING

New tapered Zippertubing offers a tight-fitting cable jacket for cables of decreasing diameters due to branch-outs. Supplied to customers' specifications.—*Zippertubing Co.*, 752 *S. San Pedro St., Los Angeles* 14, *Calif.*

CIRCLE 322 ON READER-SERVICE CARD

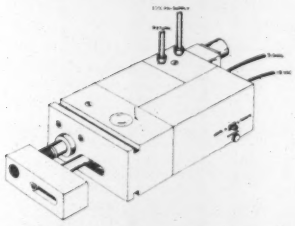
DIELECTRIC TEST SET



New Model K3-4Y simultaneously tests 10 reels of wire or cable; features independent fault indicator for each channel, optional timer for timed tests, zero start high voltage on hold push button, safety door interlock and external interlock, etc. Rated at 0 to 3 kv rms and 4 kva capacity.—*Peschel Electronics, Inc., Towners, Patterson, N. Y.*

CIRCLE 323 ON READER-SERVICE CARD

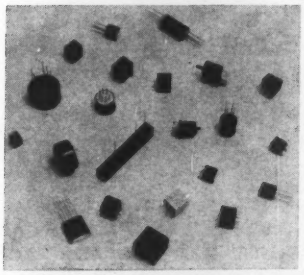
SERVO ACTUATOR



New Model 410 is a self-contained servo-actuator, containing a servo amplifier, servo valve and hydraulic cylinder for high-performance positioning. Any stroke length from 1" to 6", and cylinder diameters from 1¼" to 2½" available. Output thrust at full piston speed is up to 5 tons. Speeds are up to 40"/second and frequency response to 40 cps (90° lag). —*CompuDyne Corp., Hatboro, Pa.*

CIRCLE 324 ON READER-SERVICE CARD

LOGIC MODULES



New Collector Gated 1200 Series, General Purpose 2100 Series, and NOR/NAND 300 Series modules are available in sizes, shapes, and terminal configurations to suit packaging problems.—*Computer Techniques, Inc., 3300 Northern Blvd., Long Island City 1, N. Y.*

CIRCLE 325 ON READER-SERVICE CARD

DATA RECORDERS EXPENSIVE?

not any more

NEW

Mnemotron model 204

RECORD / REPRODUCE SYSTEM

COMPLETE WITH TAPE TRANSPORT

Features: Any 2 adjacent speeds: 1⅞, 3¾, 7½, 15 ips
Other speed ratios available
Frequency Response:
• 0-800 cps @ 15 ips • 0-200 cps @ 3¾ ips
• 0-400 cps @ 7½ ips • 0-100 cps @ 1⅞ ips
Noise: Less than 50 db below full scale. **Linearity:** 0.2% of full scale. **Crosstalk:** below 70 db

MNEMOTRON CORPORATION

now—0.2% precision in a complete, easy-to-use 4-channel analog tape system... only **$2,950**

Now you can afford the precision data recording facilities you need . . . as few as 2 channels, as many as 4, 6, 7, on ¼" tape; and 14 on ½" tape. Pioneered by Mnemotron's unique pulsed FM principle and fully transistorized, self-contained, interchangeable modules.

RECORDS ALL ANALOG DATA DOWN TO—AND INCLUDING—DC IN ALL THESE INDUSTRIAL AND RESEARCH APPLICATIONS:
• Data acquisition, storage, analysis & reduction • Time scale contraction and expansion • Dynamic Simulation • Programming • Computer Read In and Read Out

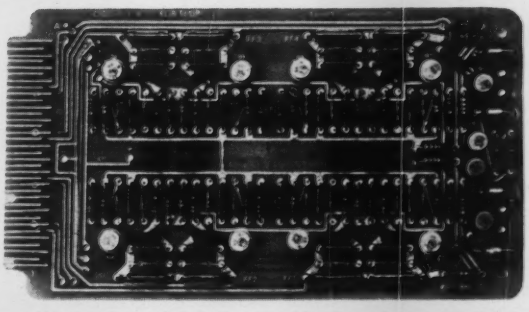
EXPANDS USEFULNESS OF PAPER RECORDERS
• Extends frequency response and channel capacity • Saves you from being "snowed" with data. • Lets you look at same data at different time scales • A permanent record even if paper is damaged

Write for complete application, price and delivery information on Mnemotron Analog Data Tape Systems and Computers for your specific needs.

Systems with voice as well as data channels also available.

41 South Main Street, Pearl River, New York
Pearl River 5-4015 (914) • Cables: Mnemotron
Precision Analog Data Tape Recorders and Biological Computers

CIRCLE 135 ON READER-SERVICE CARD



Featuring military reliability at commercial prices

EPSCO DIGITAL CIRCUIT CARDS CUT COST OF SYSTEM BUILDING

HERE'S WHY! High Circuit Density: Up to 10 circuits per card. • **Flexibility:** Use one card for several logic functions. • **Wide Loading Tolerances:** Fan out ratios up to 12. • **Reliability:** Component failure rates, less than 1 per 20 million hours. • **Compatibility** with Epsco circuit modules, shift registers and storage elements. • **Completeness:** Storage, counting, gating, amplification, timing, input-output circuits available. • **Additional Features:** Plated through holes, funnel eyelets or other types per your specifications — Field proven connectors — Readout indication, front and rear testing. Regardless of the magnitude of your needs (whether standard or special) you get the same high reliability with Epsco Components. Write for standard reliability description.

Epsco COMPONENTS

A Division of Epsco, Incorporated, 275 Massachusetts Avenue, Cambridge 39, Mass.

CIRCLE 136 ON READER-SERVICE CARD

Ranges: 15—30—60—100—160—200—300—600 and 1000 lbs. Also 30" vacuum. All gauges 2½" dial; ¼" bottom connection.

A gauge that *fits in*—to a wide range of plant and original equipment uses.

MARSH

GAUGES • THERMOMETERS • VALVES

Have you seen the New MARSH "Service Gauge"?

A remarkable new series of 2½" gauges brings you quality, accuracy and stamina—along with REAL economy!

All gauges have strong 2½" bonderized case and brass screwed ring with bevelled glass. All have new Marsh "Read-easy" dial. All are *standard* with Marsh "Recalibrator." Every gauge is guaranteed accurate within 1% of dial reading.

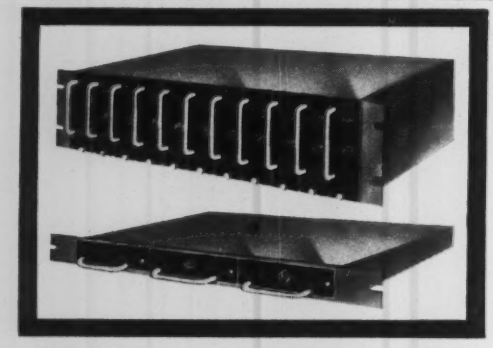
Two types covering wide range of needs available: Type 11 with copper-alloy bourdon tube, silver brazed, and bronze-bushed movement. Type 11S with 316 stainless steel bourdon tube and 303 stainless tip and socket; stainless steel and monel movement.

Ask For New Bulletin

MARSH INSTRUMENT COMPANY
Dept. 42, Skokie, Ill.
Division of Colorado Oil & Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas. Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N.J.

CIRCLE 137 ON READER-SERVICE CARD

the most advanced tone-signalling equipment available



by EXPERIENCED SPECIALISTS

Quindar **ELECTRONICS, INC.**

TECHNICAL HIGHLIGHTS

- **Modular construction—plug-in units and frequency components**
- **Interchangeability of AM and FS transmitters and receivers**
- **Any combination of up to 10 Am and FS transmitters and receivers plus power supply in 5¼" x 19" rack**
- **AC/DC operation—117 VAC or 12 VDC with automatic switchover to standby battery**
- **Individual input/output line coupling to transmission circuit for each module**
- **Individual test sockets for all modules featuring go-no-go testing**
- **One transistor type used for all transmitters and receivers**
- **Reliable, practical and economical**

Quindar transistorized AM (ON/OFF Type) and FS (Frequency Shift) audio tone transmitters and receivers—for telemetering and control systems—are the most advanced design of any tone signalling equipment available. In module form, they are completely interchangeable, compact and economical—any combination of up to 11 modules can be mounted in a 5¼" x 19" rack including power supply. Three modules fit snugly in a 1¾" x 19" rack. This versatile design philosophy overcomes the problems of system expansion, rising costs and space economy.
Over 24 years of experience are now concentrated for new designs...equipment for the future.

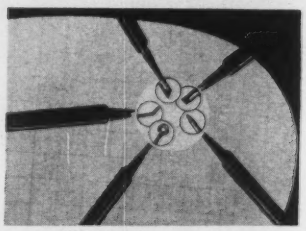
WRITE FOR DETAILS

Quindar **ELECTRONICS, INC.**

5 LAWRENCE STREET, BLOOMFIELD, N.J.

CIRCLE 138 ON READER-SERVICE CARD

MICROMINIATURE TOOLS



New Microtool line of Hand Tools embodies 67 active elements from 0.001" to 0.01". Each tool is designed to do a specific microelectronic or instrument job in the best possible way. Bulletin.—*Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif.*

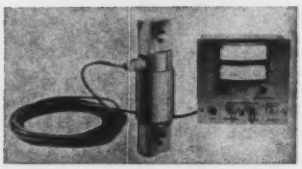
CIRCLE 326 ON READER-SERVICE CARD

POWER SUPPLY

New precision 25-va a-c Power Supply has output frequency of 350-450 cps; amplitude and frequency stability, 0.1%; regulation, 1% 0-full load; output, variable 0-130 v.—*Industrial Test Equipment Co., 55 E. 11 St., New York 3, N. Y.*

CIRCLE 327 ON READER-SERVICE CARD

FORCE METERS



New transistorized SIDCO Force Meters measure tensional, torsional, or compressive forces to 20,000 lb with ±2% accuracy. Units consist of sensing cell, internally calibrated transistorized indicating meter, connecting cable, and battery case.—*Plastronics Div., Plastic Applicators, Inc., Box 7631, Houston 7, Texas.*

CIRCLE 328 ON READER-SERVICE CARD

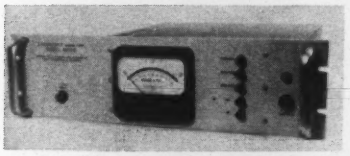
LIMIT STOP ASSEMBLY

New 50-turn Limit Stop Assembly accomodates up to 8 settings, operates by push-rod-plunger assemblies. Switch actuation accurate to ±5° or 0.027%. On cam-actuated switch can be added, will repeat to ±2° or 0.011%. Units include anti-backlash device, end-position energy-absorbing springs.—*United Control Systems, Inc., 918 Woodley Rd., Dayton 3, Ohio.*

CIRCLE 329 ON READER-SERVICE CARD

FREQUENCY MONITOR

New frequency monitors utilizing Magmeter® detector principle indicate the true frequency of a 400 cps



source with an accuracy of 100 parts per million, also drive recorder of approx 500 Kohms impedance.—*Airpax Electronics, Inc., P.O. Box 8488, Ft. Lauderdale, Fla.*

CIRCLE 330 ON READER-SERVICE CARD

THERMOCOUPLE

New rugged, adaptable thermocouple for high temp and pressure applications—gas turbine and internal combustion engines, steam generators, oil and chemical processes, etc.—is supplied with high temp terminal block 1⅛" dia, and MgO insulated sheathed thermocouple elements. Available in all common calibrations and sheath materials in diameters from 0.062 through 0.250. Junctions supplied either grounded, ungrounded or exposed.—*Thermocouple Products Co., Inc., 729 N. Addison Ave, Villa Park, Ill.*

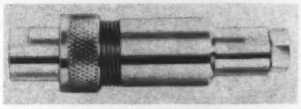
CIRCLE 331 ON READER-SERVICE CARD

R-F POWER BRIDGE

New precision R-F power bridge Model PB-1 is designed for use with 200-ohm bolometer mounts using either 4.5 or 8.75 ma barretters or a pair of 13-ma thermistors. Accuracy of ¼% in substituted power is achieved between 500 μw and 20mw.—*Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.*

CIRCLE 332 ON READER-SERVICE CARD

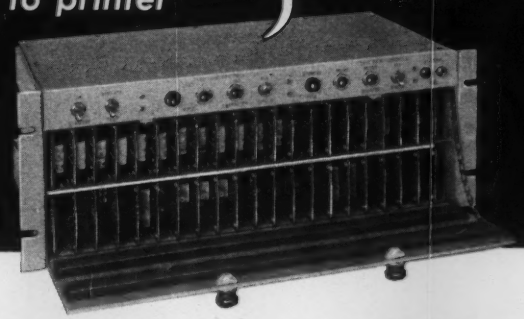
THERMOCOUPLE CONNECTOR



New waterproof quick-disconnect Thermocouple Connector is available for applications in extreme moisture and corrosion conditions, for installation directly to thermocouple assemblies or in "inline" applications requiring quick disconnect. The unit splices lengths of sheathed thermocouple wire, adapts to all standard sized sheathed thermocouples and to flexible hose leadwire enclosures.—*Thermo-Couple Products Co., Inc., 729 N. Addison Ave., Villa Park, Ill.*

CIRCLE 333 ON READER-SERVICE CARD

tape to printer
card to printer
processor to printer
adc to printer
BUFFERS



It's almost **sinfully** easy to drive rotary-bar printers when you use DI/AN's RBP Series Buffer and Control Units. All the control functions, accessory features, and format flexibility a reasonable man could want — in a surprisingly compact package. We leave room for three extra cards—for unreasonable special requirements. All solid-state, magnetic-storage circuitry with proven reliability. Price and delivery will discourage you from building your own.

We want to send you a handful of specification and applications literature on our complete line of sequential-access and special-purpose buffers. Fascinating reading. Write **today.**

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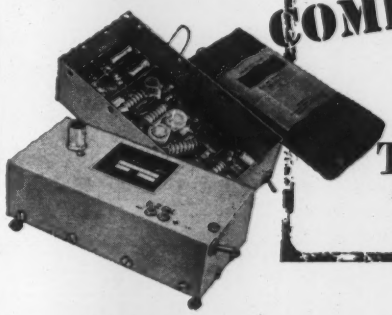
magnetic digital/analog systems and components

CIRCLE 139 ON READER-SERVICE CARD

new! from Frontier

COMPACT-RUGGED
UHF TELEMETERING TRANSMITTER



NEW TT-1001 UHF TELEMETERING TRANSMITTER gives accurate and stable CW Signal for radio direction finder tracking of missiles or vehicles. Unit is completely transistorized with a self-contained regulated power supply. Easily installed, high accuracy and stability under extreme environment. Write for Bulletin 101-D.

- Low power drain, fully solid state
- WT: 6.5 oz. w/o battery
- Frequency: 225-245 m.c.
- Power Output: 260 milliwatts

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CIRCLE 140 ON READER-SERVICE CARD

how to measure in-phase and quadrature with 0.1% accuracy—in milliseconds

Previously unobtainable accuracy and millisecond response are only two of the reasons why NAI's Phase Sensitive AC-to-DC Converters meet the most critical requirements in computer, recording, automatic test and digital display systems.

Unlike conventional converters, these all solid state modules measure **not only total signal—but quadrature, in-phase and fundamental components as well.** DC output is proportional to selected input component, yet unaffected by harmonics. A wide range of manual and relay-actuated models permits selection and programming of function, range and frequency to suit test or system requirements.

Specifications of relay-programmed models are given in the table. Data on manually switched models PSC-415 and -416 upon request.

		PSC-410/411	PSC-420/421
Voltage Range	(410 & 420)	1 v f.s. to 300 v f.s., 4 ranges	
	(411 & 421)	10 mv f.s. to 300 v f.s., 6 ranges	
Frequency Range	(phase sens.)	1 frequency*	3 frequencies*
	(total volts)	60 cps–20 kc	60 cps–20 kc
Linearity		0.1% f.s.	0.1% f.s.
Functions		E_f, E_f, E_{in} and E_q	
Output Voltage		0-10 v dc, into 10 k load, for all functions	
Input Impedance		1 megohm	1 megohm
Response Time		0.1 sec	

*any frequency between 60cps and 10kc.

The North Atlantic man in your area can quickly show you how the PSC-410 and -420 simplify AC measurement jobs from GSE to production test of transducers, networks and amplifiers. Call today for his name, or request Bulletin PSC-1.

NORTH ATLANTIC *industries, inc.*
TERMINAL DRIVE, PLAINVIEW, L. I., NEW YORK • OVerbrook 1-8600

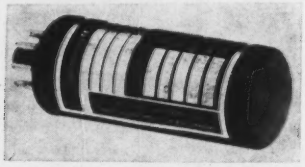
CIRCLE 141 ON READER-SERVICE CARD

OSCILLATOR FOR CYCLE TEST

New Servo-Gauge Oscillator, a pneumatically actuated timer without moving parts or electrical connections, features case for panel or surface mounting, and removable mounting plate for all components. Signaling impulses are adjustable in frequency between 0.3 and 60 cpm. They are essentially rectangular waves which can be preset in amplitude between 0 and 30 psig.—*Associated Control Equipment, Box* 136, *Coraopolis, Pa.*

CIRCLE 334 ON READER-SERVICE CARD

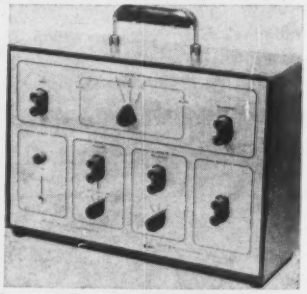
TRANSISTORIZED TIMER



New Model MT-1103 replacement for all thermal relays provides instant rest with repeat accuracies of 3% under voltage and temperature variations, integral or remote time adjustment, with time delay variation from ½ to 100 seconds.—*Syracuse Electronics Corp., P. O. Box* 566, *Syracuse* 1, *N. Y.*

CIRCLE 335 ON READER-SERVICE CARD

AC/DC & DC/DC COMPARATOR



New, unique instrument is a precision summer-limiter-amplifier-limiter based on operational amplifier techniques. Peak ac may be compared to dc with 0.005% accuracy, dc to dc with 0.001% accuracy. Also enables use of ordinary scopes to precisely observe small portions of large waveforms without oscilloscope overload. —*Rotek Instrument Co.,* 733 *Concord Ave., Cambridge, Mass.*

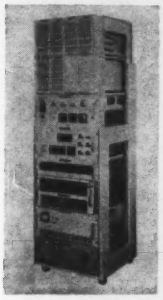
CIRCLE 336 ON READER-SERVICE CARD

IN-LINE BLENDING SYSTEMS

New systems for in-line blending of fluid components comprise (1) turbine flowmeters on each fluid line, (2) digital comparators that compare deviations from preset flows by comparing counts from turbine flowmeters, (3) ratio setters that scale the counts to obtain any desired ratios and individual flows, (4) electronic controllers that receive analog-signal from comparator and perform desired control action—proportional, reset, or rate, (5) diaphragm output control valves to control flows to achieve any desired blends. Accessories include readouts, totalizers, etc. System can accomodate any number of components.—*Fischer & Porter Co., 801 Jacksonville Rd., Warminster, Pa.*

CIRCLE 337 ON READER-SERVICE CARD

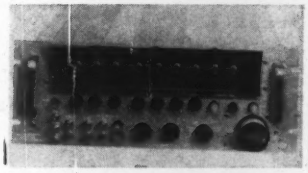
STRAIN GAGE DATA LOGGER



New Model 179 Strain Gage Logger contained in one standard 19" relay rack is a medium speed, absolute millivolt instrument, which scans 200 channels of strain data at 5 channels/sec. Prints data out on paper tape; also has high-speed tape punch system. Ranges are zero to 5000, or zero to 10,000 μin/in.—*Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.*

CIRCLE 338 ON READER-SERVICE CARD

TIME CODE GENERATOR



New Model 275 Time Code Generator is made in three types, Type A, Type B, and Type C, which differ in the format of the time code outputs. Solid-state instrument generates 6 time code outputs for high and low speed analog magnetic tape recorders, oscillographs, or data recording cameras. A seventh is a 42-bit parallel output used for digital acquisition systems or on-line computer applications. Included is a semi-automatic WWV synchronizing circuit. Bulletin 275.—*Hermes Electronics Co., Div. of Itek Corp., 75 Cambridge Parkway, Cambridge 42, Mass.*

CIRCLE 339 ON READER-SERVICE CARD

MODEL RMT
NOW
specific
GRAVITY RECORDING
OF LIQUIDS AT ANY
DISTANCE
Accurate long-distance transmission of specific gravity recordings is no longer a problem with any of the new RMT Models of Arcco-Anubis Recording Gravitometers for recording and transmitting liquid gravity records. These instruments combine the mechanism of the standard Arcco Liquid Gravitometer with a metameter telemeter transmission system which records and transmits the specific gravity record to control room or other remote location. The inter-connecting line may be any two-wire electrical circuit or its equivalent: private wires, telephone circuits, carrier current channels, or radio (VHF or UHF).
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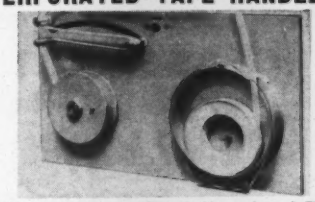
MANUFACTURERS OF PRECISION INSTRUMENTS

CIRCLE 142 ON READER-SERVICE CARD

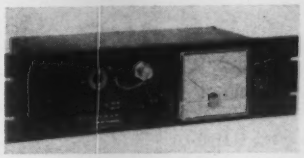
PERFORATED TAPE HANDLER



New high-speed uni-directional Perforated Tape Handler, Dykor Model 4544, handles 500 ft of 5- to 8-level tape interchangeably, at speeds up to 500 characters/sec (50 inches/sec). Designed to function with the Dykor uni-directional Model 3500 photoelectric tape reader.—*Digitronics Corp., Albertson, N. Y.*

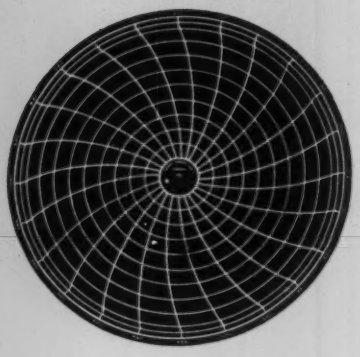
CIRCLE 340 ON READER-SERVICE CARD

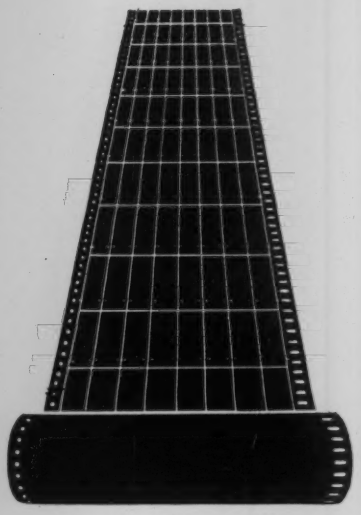
CAPACITANCE TEST SET



New Model 1827 C_{ob} Test Set provides direct meter readings of the collector capitance of transistors with ranges of 0-3, 0-10, 0-30 and 0-100 μμfd full scale. Accuracy is 5%. Can also be used to measure capacitance of diodes when reversed biased.—*Dynatran Electronics Corp., 178 Herricks Rd., Mineola, N. Y.*

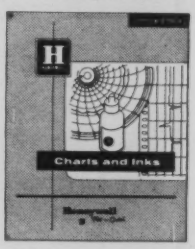
CIRCLE 341 ON READER-SERVICE CARD





INSTRUMENT CHARTS

Strip charts available in 3, 4 and 12 inch widths, circular charts in 8, 10 and 12 inch diameters. Made to resist expansion, shrinkage, humidity, dryness and heat. Close control of sizing gives clear record lines with minimum pen pressure. Charts are among the many thousands of accessories—all from a single dependable source—that can help your instruments perform at their very best.



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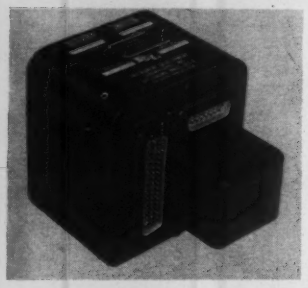
CIRCLE 143 ON READER-SERVICE CARD

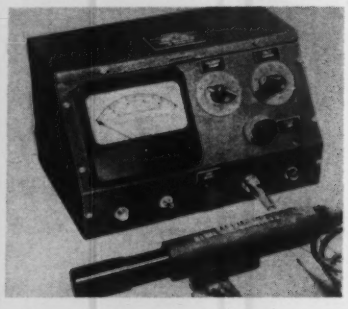
FUNCTION GENERATOR SWITCH



New 3600 rpm electro-mechanical switch incorporates: (1) Incremental saw-tooth function generator providing 30 steps of 0.16 v each and (2) 60-position shorting type scanning switch. Driven by 400 cps 115 v motor, similar techniques can generate almost any function.—*Instrument Development Laboratories, Inc., 67 Mechanic St., Attleboro, Mass.*

CIRCLE 342 ON READER-SERVICE CARD

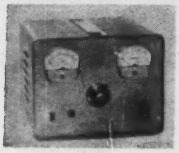
RADIATION PYROMETER



New Model PY40 non-contacting radiation pyrometer is activated by infrared radiation emitted by objects 300°F upward over distances of many feet. Outputs include visual meter indication, 0-100 mv dc recording output and on-off 2-position relay control with contacts rated at 5 am @115v. —*Mason Instrument Company, Inc., P. O. Box 683, Mamaroneck, N. Y.*

CIRCLE 343 ON READER-SERVICE CARD

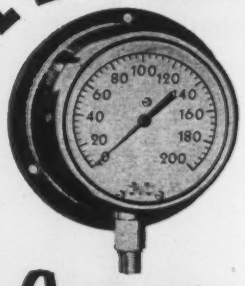
REGULATED DC POWER SUPPLY



Miniature Model PS 120 solid-state low voltage power supply for transistor circuits, strain gages, etc. has output of 0-10 v dc, 0-1 amp from 105-135 v ac line. Regulation is 0.002% for 10% line voltage change and 0-200ma load.—*Dynex Industries, Syosset L. I., N. Y.*

CIRCLE 344 ON READER-SERVICE CARD

MARSHALLTOWN



Gauges

The right gauge for your specific needs

A complete line of gauges in stock available for early delivery. Gauges from 10-inches water pressure to 30,000 P.S.I. to meet your specifications on any equipment.

- Pressure
- Vacuum
- Compound
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- Combination
- Diaphragm
- Hydraulic
- Special Purpose
- Dial Thermometer (Vapor Tension or Bi-Metal)

Let Marshalltown answer your gauge problems . . . write for information and prices.

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Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contact Cutters of Tube and Rod.

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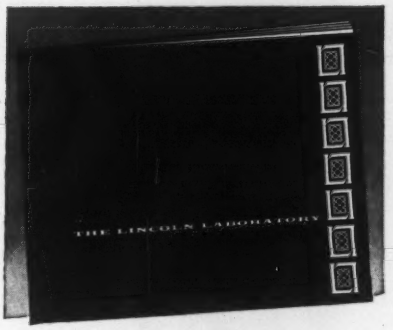

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LEXINGTON 73, MASSACHUSETTS

Help The Medical Field:

(*Cont. from page* 973

Blood Flow in Animals

Ph.D., assistant professor of physiology at university school of veterinary medicine, wishes to measure blood flow in vessels of conscious animals. Method must be different from measurement of N_2O concentrations across the organ after inhalation of 15% N_2O. M-22

Cerebral Blood Flow

Associate chief of neurology at V. A. center is interested in radioisotope measurements of cerebral blood flow. M-23

Intra-ocular Pressure

President of research company is interested in intra-ocular pressure measurement for glaucoma in the range of 15 to 50mm Hg. (Other than tonometer). M-24

Tape Recorder

Owner of medical company seeks professional-grade magnetic tape recorder, relay operated, 2-track, with 3¾ and 1½"/sec speed. M-25

Differential Amplifier

Director of instrumentation lab at university medical school seeks low-noise, low-drift, high-impedance-input, d-c differential amplifier or pre-amplifier for nerve preparations, etc. Signal—40 uv; bandwidth—0.10 kc. M-26

Low-level Radiation

City public health engineer wishes to measure low-level radiation in environmental samples ($\mu\mu$curies). M-27

Automatic Fluorometer

Research chemist in hospital lab seeks fluorometer equipped with automatic sample changer. M-28

Blood Pressure Recorder

Psychologist at medical school wishes to record blood pressure in rabbits and humans. M-29

Oxygen Tension

Institutional physician wishes to measure oxygen tension through cardiac catheter tip to avoid taking blood samples from different chambers of the heart during cardiac catheterization. M-30

Cardiographic Scope and Camera

Doctor at university medical school requests information on cardiographic scope and recording camera combinations. M-31

(*Continued on* 1140)

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Nuclear Gages for Process Measurement and Control!

Obtain continuous, close limit control of:

- Specific gravity and density of liquids.
- Percent solids or moisture of slurries.
- Level or interface position of liquids, solids, slurries.
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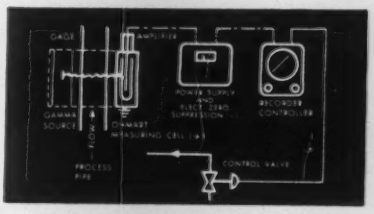
- Thickness or weight of moving webs of sheet materials.



Typical Ohmart Density Control System where control of liquid density is by actuation of a valve. No part of the gage contacts the process material.

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CIRCLE 146 ON READER-SERVICE CARD

NEW DE-LINE annunciator has

70% MORE ENGRAVING AREA for more precise trouble legends

Scam De-Line annunciators, your systems' sentry, now offers the new MAGNA-PLAC nameplate which provides 70% more engraving area.

The MAGNA-PLAC nameplate gives the engineer increased space to more accurately describe condition variations or to employ larger characters for greater visibility. It is interchangeable with standard Scam nameplates and optionally available *without extra charge.*

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NAME .....

CIRCLE 147 ON READER-SERVICE CARD

HELP THE MEDICAL FIELD:

Muscle Tension

Assistant professor of pharmacology at university medical school wishes to measure isometric tension of smooth and cardiac muscle in the range of 50 mg to 10 gm. M-32

Arsenic in Body Fluids

Private physician wishes to measure arsenic in body fluids. M-33

Binocular Microscope

Director of clinical-medical laboratory is seeking binocular microscope. M-34

Blood Pressure Recording

Professor of physiology seeks recorder for human blood pressure. M-35

Particles in Oil

Senior engineer of aircraft manufacturer wishes to measure particle size distribution of contamination in 100 ml of hydraulic oil. Size ranges: 5-15μ; 15-25μ; 25-50μ; 50-100μ. M-36

Mean Systemic Pressure

Director of pharmacology labs for pharmaceutics manufacturer wishes to measure mean systemic blood pressure in unanesthetized moving dog. Range: 40-280 mm Hg. M-37

Brain Wave Telemetering

Assistant professor of university medical school wishes to measure brain waves from experimental cat in motion, telemetered (wireless) from FM transmitter (with several channels) mounted on animals. Range: 10 to 1000 uv; frequency: dc to 1000 cps. M-38

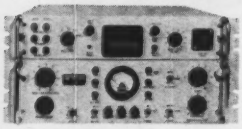
Recording Densitometer

Instructor of surgery in college of medicine seeks instrument for densitometric analysis of cineangio films, with graphic recording. M-39

Buildings Wired for TV, Paging, Monitoring

Electronics associate in college of medicine planning new buildings requests data on wired TV, paging, centralized monitoring. M-40

MACHINES TALK!



over commercial telephone circuits equipped with Rixon's fully transistorized, low error rate, highly reliable Sebit-24 Transmitter-Receiver.

Binary information is processed 600/1200/2400 bits/second in a nominal 3-KC voiceband such as a long distance toll circuit. High speed data passage of: 3000 W/M teleprinters; machines and computers; slow scan TV; facsimile; time division multiplexers; and sequential telemetering equipment.

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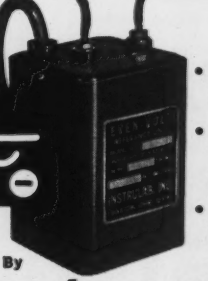
CIRCLE 148 ON READER-SERVICE CARD

INSTRULAB'S
Temperature Compensated
evenvolt
Constant Voltage Unit



Replaces Batteries and All Standardizing Components Including Standard Cell In
POTENTIOMETERS
• CONTROLLERS • INDICATORS
• RECORDERS

Mfg. By
INSTRULAB, INC.
1205 Lamar Street
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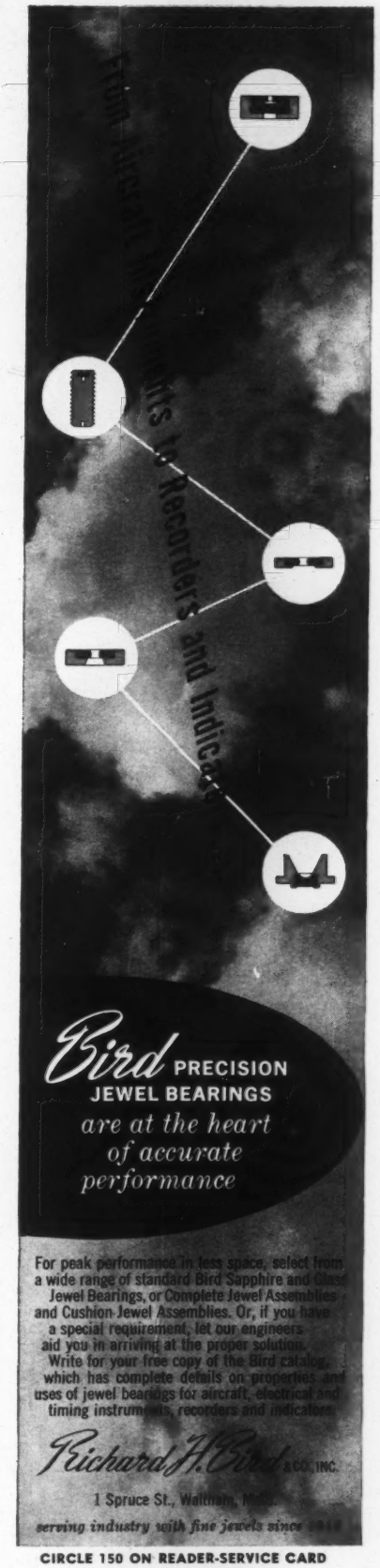
Outstanding FEATURES
- Eliminates batteries ...errors due to battery exhaustion
- Reliable construction...from quality components, long, trouble-free service
- A Precise voltage regulator . . . max. ±.04% for ±20% voltage variation
- Quickly Installed... Fits present instrument battery space.
- No Tubes to replace

CIRCLE 149 ON READER-SERVICE CARD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JEWEL BEARINGS
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performance
For peak performance in less space, select from a wide range of standard Bird Sapphire and Glass Jewel Bearings, or Complete Jewel Assemblies and Cushion Jewel Assemblies. Or, if you have a special requirement, let our engineers aid you in arriving at the proper solution. Write for your free copy of the Bird catalog, which has complete details on properties and uses of jewel bearings for aircraft, electrical and timing instruments, recorders and indicators.
Richard H. Bird & CO., INC.
1 Spruce St., Waltham,
serving industry with fine jewels since

CIRCLE 150 ON READER-SERVICE CARD

Pad Saturation

Medical technician in county hospital needs method to measure saturation of ABD pad used to cover surgical incisions, with alarm for nurse when pad becomes saturated by blood or body fluids. M-41

Blood Dielectric Constant

Director of research in biological research laboratory wishes to measure dielectric constant of blood. M-42

Eye Movement

Research assistant in hospital department of neurology requires method to measure eye position and eye movements for neurological research and diagnosis. Range: 0.1° to 100°. M-43

Tissue Resistance

Professor of obstetrics and gynecology at university requires measurement of tissue resistance and potential. M-44

Heart Currents, Potentials

Assistant plant physician of refinery wishes to measure human heart currents and voltages for diagnostic analysis purposes. Ranges required 0-3 mv; 0.50 kcps. M-45

Fetal ECG

Supervisor of medical research in hospital is interested in fetal ECG. M-46

Mini Lamp

Director of anesthesia at state university hospital needs small (1 to 2 mm dia), high intensity, low-voltage (less than 9v) light, giving off little heat, for application requiring contact with mucous membranes without danger of burning. M-47

Abnormal Cytology Detection

General practitioner needs information on ultraviolet adaption of regular binocular microscope for fluorescent detection of abnormal cytology with staining of DRNA and DNA differentially to detect possible cancer. M-48

Fluorescence Measurement

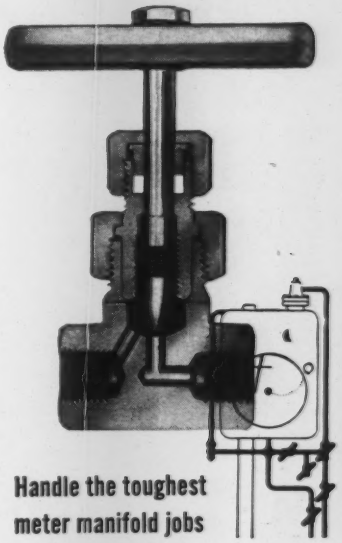
Medical technician in U. S. Naval Medical School wishes to measure fluorescence of proteins by other method than electrophoresis plus photofluorometer. M-49

Relative Humidity

Electronic development technician in life science department of missile center wishes to measure percent relative humidity (in low pressure chamber and aircraft use) at altitudes above 20,000 ft. M-50

For dependable field service

SPECIFY AMERICAN® NEEDLE VALVES



Handle the toughest meter manifold jobs and corrosive field services. Eliminate gland leaks.

Teflon-packed forged steel American® Needle Valves deliver year 'round dependable service—stand up under all conditions. Stainless or carbon steel precision machined valve bodies are ideally suited for welding. Stainless steel centerless-ground valve stem design makes it simple to repack valves under pressure.

Standard valves are design rated for pressures to 5,000 psi at 70°F. Upon request, assembled valves are hydrostatically tested to 10,000 psi (twice rated working pressure) and individually inspected. Valves are also furnished with graphite-impregnated asbestos packing for temperatures above 450°F.

Angle or straight patterns—screwed or union bonnets.

Ask your American Meter representative for full details.

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General Offices:
Philadelphia 16, Pa.
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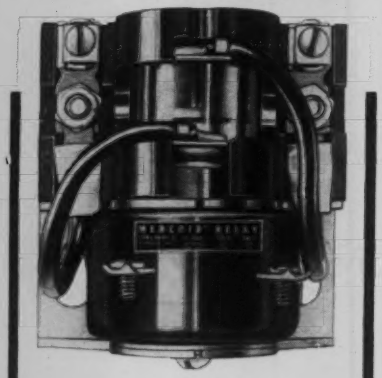
CIRCLE 152 ON READER-SERVICE CARD

35 AMP

* 120V. Non-Inductive A.C. heater loads

Plunger Type

MERCURY RELAY



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If you need reliability and durability, this quality built relay by Mercoid is your answer.
For heavy duty loads, such as resistance heating, (domestic, commercial, industrial)—heat treating furnaces, drying equipment, welding, lighting, illuminated signs, score boards.
Hermetically sealed mercury to mercury contact provides visible on-off operation. Silent and chatterless. Quickly mounted, easily wired. Speeds up to 100 operations per minute.

Available normally open;

CONTACT RATING:

LOAD			*NON INDUCTIVE HEATER LOADS	
	AC	DC	AC ONLY	
120V.	30A.	15A.	120V.	35A.
240V.	20A.	10A.	240V.	25A.
440V.	8A.	—	440V.	10A.

WRITE FOR BULLETIN 0-20

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

CIRCLE 153 ON READER-SERVICE CARD

HELP THE MEDICAL FIELD:

Low Resistance Slip Rings

Electronics technician at university medical college desires information on technique for use of low-torque, low-resistance slip rings in medical biophysics with no resistance change when slip ring rotates. ("Hg pools do exhibit R changes.") M-51

Oxygen and CO_2 in Blood

Doctor in children's hospital wishes to measure both saturation and partial pressure of oxygen and CO_2 in blood, as well as flows in heart lung machine. M-52

Bone Motion

Director of research affairs at college of osteopathic medicine and surgery wishes to measure motions of cranial bones at suture (joint) lines for diagnosis of cranial structure-function abnormalities. Now using palpatory technique. M-53

pH, Blood Flow Recording

Chief surgeon at V. A. hospital wishes to measure and record pH and blood flow in operating room. M-54

Fetal Respiration in Rats

Research Associate in medical center department of anatomy requires fetal respiratory measurements in rats, guinea pigs, rabbits; especially intrapulmonic pressure, with miniature pickup most essential. (Also would like to measure heart rate in unrestrained, unanesthetized rats.) M-55

Intrauterine Pressure

Research Assistant at university medical center wishes to measure rat intrauterine pressure for research in role of pressure in sperm migration. Presently using open-end catheter in uterus, plus transducer, plus recorder. M-56

Bedside Analysis

Associate university professor of surgery wishes to measure Na, K, Cl, pCO_2, serum and cerine at bedside to avoid transfer of specimens to main lab. M-57

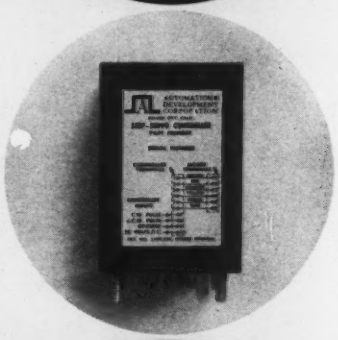
Blood Pressure Recorder

Hospital doctor wishes to record blood pressure of pregnant patients. M-58

Physiological Acoustics

Assistant professor in department of otolaryngology of university school of medicine requires information on "audiometrics and physiological acoustics." M-59

new STEP-SERVO motors & controllers



FOR RELIABLE DIGITAL / ANALOG CONVERSION

SIZES 5-8-11-15-23 IN STOCK; OTHERS AVAILABLE

Convert pulse data to accurate shaft rotation without feedback circuitry. Patented control logic steps bi-directional motor in 45°, 90°, 180° or 360° increments up to 250 pps. Magnetic detenting eliminates wear and shock-loading. Accuracy to minutes of arc per step is possible with available gearheads. Also used to convert analog input to pulse data by addition of gating circuit. Designed to MIL-E-5400C and MIL-E-5272B. Write for catalog.

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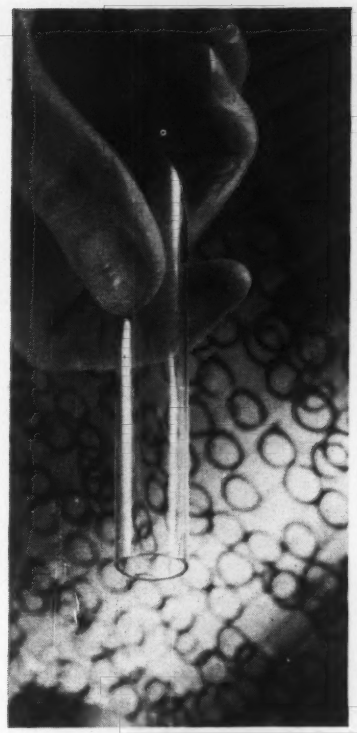
CULVER CITY, CALIF.

CIRCLE 154 ON READER-SERVICE CARD



THIS TUBING CAN SAVE YOU MONEY

This special CORNING® flint glass tubing and rod give you ease of forming, strength, and topflight transparency. They are priced up to 50% lower than PYREX® tubing and rod. They are available immediately.

We developed CORNING brand 0088 flint glass just for the making of low-temperature-service tubing and rod. In uses near room temperature, it resists chemicals almost as well as PYREX brand glasses.

A statistical profile: coefficient of expansion, 92 x 10^{-7}; softening point, 700° C.; annealing point, 521° C.; strain point, 480° C.

We put this glass into apparatus tubing with outer diameters which range from 3 to 51 mm, in capillary and barometer tubing with inner diameters from 0.5 to 4 mm, and in rod with diameters from 3 to 12 mm. All are furnished in 48-inch lengths.

You can get any type in any quantity, quickly. For information on our entire tubing and rod line, write for Bulletin TBG-88.

CORNING GLASS WORKS
10006 Crystal St., Corning, N. Y.
CORNING MEANS RESEARCH IN GLASS

CIRCLE 155 ON READER-SERVICE CARD

HELP THE MEDICAL FIELD:

Negative Ion Generators

Electronics development technician in government lab requires information on negative ion generators. M-60

Heart Sound Recording

Doctor with private practice wishes to find simple inexpensive way of recording heart sound on electrocardiograph in office. M-61

Tissue Culture and Cytology

Research associate in hospital department of pathology is interested in acquiring information on techniques applicable to tissue culture and cytology. M-62

Physiological Telemetering

Engineer with medical instrument manufacturer wishes to obtain information on physiological telemetering and micro-miniature transducers. M-63

Tape Recording of Physiological Variables

Associate university professor wishes to tape record physiological variables (in range 0-100 cps) in EKG, EEG, blood pressure applications, etc. Has transducers, preamps on hand, producing variable d-c output. M-64

Phonocardiograms

Physician attached to hospital wishes to make "good" intracardiac phonocardiagrams. M-65

Protein and Amino Acid Comparisons

College professor of biology wishes to compare proteins and amino acids in related species of toads. Now using chromatographic spectrophotometric or histochemical techniques. M-66

R-F Harmonics

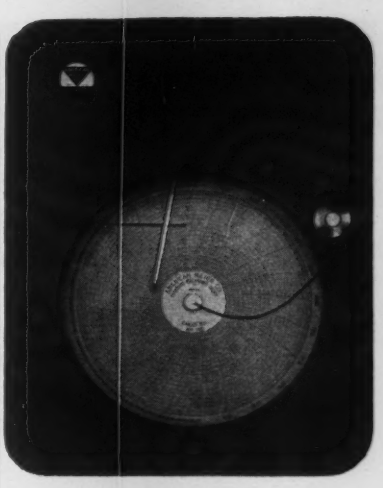
Electrical engineer wishes to measure R-F harmonics (interference to transmitters) of power supplies by other method than scope filters. M-67

Audio Analgesia

Treasurer of micrometer manufacturer wishes to measure Gaussian noise sounds in audio analgesia. M-68

Blood Flow, Pressure

Consulting engineer with electronics lab of prominent electric manufacturer wants to measure blood flow and hydrostatic pressure. M-69



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PRESSURE and TEMPERATURE RECORDERS

American® single and two-pen *Pressure Recorders* for pressures from 30 inches vacuum to 10,000 psi.

- Pressure elements individually calibrated over full range.
- Variety of chart drives available.
- Helical elements of different ranges are interchangeable.
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- No ambient temperature errors.
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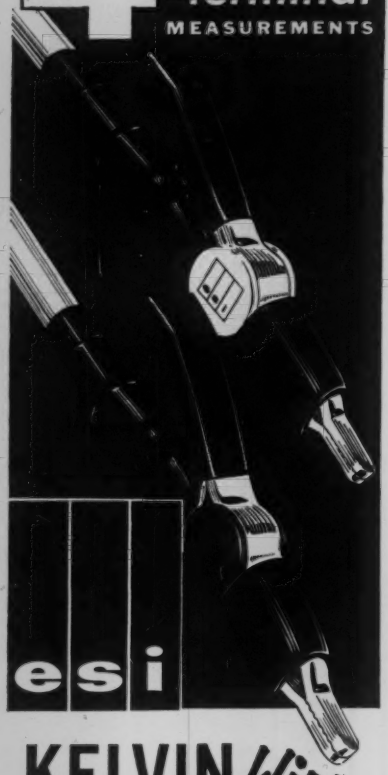
CIRCLE 156 ON READER-SERVICE CARD

NEW!

FOR HIGH ACCURACY

4-terminal MEASUREMENTS



KELVIN *klips*

- Originally developed as a precision accessory for the ultra-high-performance ESI 240 Resistance Bridge.
- Adaptable to any bridge employing Kelvin circuits and the time and labor-saving 4-terminal method by which stray resistances are forced to contribute negligible error to measurement.
- Also useful as long-life, low-resistance, all-purpose test clips for two-terminal applications.
- Positive gripping force allows rapid connections with minimum contact resistance. Maximum current rating 3 amps.
- ORDER FROM STOCK—Kelvin Klips only, $7.50 pair; completely assembled, with 24" shielded cable and gold-plated spade-lug connectors, $25.00 pair. (Ask about special quantity discounts.) Also available, the Kelvin Klamp, with foot-operated, hydraulic power for high-speed production-line use.

Send for literature . . . ESI technical bulletins on advantages and applications of 4-terminal techniques and equipment.

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CIRCLE 157 ON READER-SERVICE CARD

ICS NEW LITERATURE

CONTROL

CONTROLLERS. 8-page Bulletin A135 contains description of A/D Control Unit used in indicator, Model 624, and recorder, Model 532.—Bristol Co., Waterbury 20, Conn.

CIRCLE 345 ON READER-SERVICE CARD

COMBUSTION CONTROLLERS. 8-page Bulletin 3-001 describes with sketches combustion controls for furnaces, ovens, and boilers.—North American Mfg. Co., 4455 East 71st St., Cleveland 5, Ohio.

CIRCLE 346 ON READER-SERVICE CARD

SUPERVISORY CONTROL. 2-page Bulletin 161 describes and explains uses of transistorized Audio Tone Channels.—Quindar Electronics, Inc., 5 Lawrence St., Bldg. 9, Bloomfield, N. J.

CIRCLE 347 ON READER-SERVICE CARD

VALVES

BALL VALVES. 6-page Bulletin HTB-26 enumerates the eight important valve features that a buyer should look for in a ball valve.—Hydromatic, Inc., 5 Lawrence St., Bloomfield, N. J.

CIRCLE 348 ON READER-SERVICE CARD

BALL VALVES. 32-page Catalog 1200 gives comprehensive information on manually operated and pneumatically operated ball valves in sizes from ¼" through 12".—Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.

CIRCLE 349 ON READER-SERVICE CARD

PRESSURE, VACUUM, WEIGHT, FORCE, ACCELERATION

PRESSURE TRANSDUCER. 2-page Bulletin 4329 describes and specifies Type 4-329 Airborne Pressure Transducer.—Consolidated Electrodynamics Corp., a subs. of Bell & Howell Co., Transducer Div., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 350 ON READER-SERVICE CARD

VACUUM PRODUCTS. 16-page catalog describes high vacuum technology and products.—Vacuum Products Div., Varian Associates, 611 Hansen Way, Palo Alto, Calif.

CIRCLE 351 ON READER-SERVICE CARD

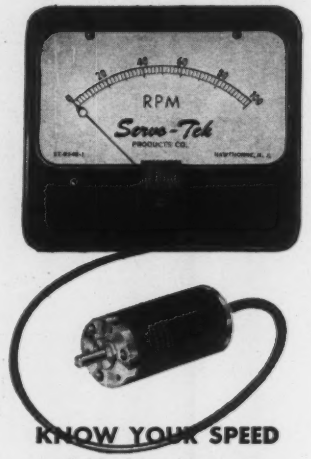
VISUAL WEIGHT INDICATION. 4-page Bulletin 658-B24 features equipment showing weights on direct reading dials.—Streeter-Amet Co., Grayslake, Ill.

CIRCLE 352 ON READER-SERVICE CARD

LINEAR ACCELERATOR. Brochure A illustrates and describes the Tayco Linear Accelerator for controlled acceleration, velocity, and deceleration under test conditions.—Tayco Developments, Inc., 188 Main St., North Tonawanda, N. Y.

CIRCLE 353 ON READER-SERVICE CARD

NEW!



KNOW YOUR SPEED
with the accurate
SERVO-TEK SPEED INDICATING SYSTEM

A truly versatile "package" provides accurate speed indication for almost anything that moves. Nearly every industrial process or machine can benefit by the economy and safety of continuous speed indication.

FEATURES

SELF-POWERED No batteries or external power required.

LOW VOLTAGE Connecting cable can be as long as 500 ft.

PERMANENTLY LUBRICATED BALL BEARINGS.

EASILY READ 4½" INDICATOR Damped to withstand vibration and shock.

STANDARD RANGES 0 to 100, 250, 500, 1000, 2000, 3000, 4000, 6000, 8000, 10,000 and 12,000 RPM. These speeds can also be provided to read "Percent of Full Speed" or "Percent of Capacity." 0 to 10 RPM available at small additional cost.

$87.00 includes generator, indicator (specify range), mounting base, coupling, and 15 ft. of electrical cable. Delivery from stock. Quantity discounts.

Servo-Tek PRODUCTS CO.

Main Office 1086 Goffle Road, Hawthorne, N. J.
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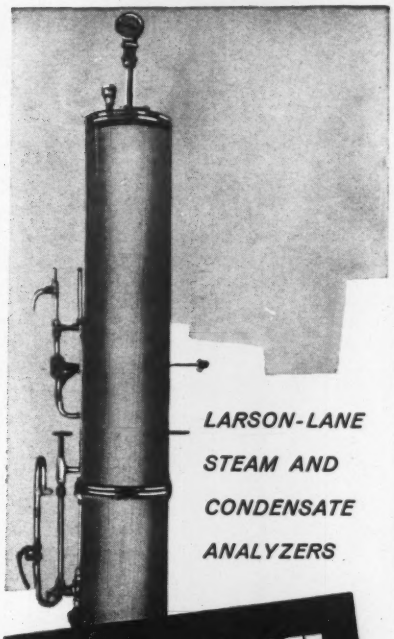


LARSON-LANE STEAM AND CONDENSATE ANALYZERS

FOR ACCURATE MEASUREMENT OF STEAM CONDUCTIVITY

MOST modern and efficient system of removing volatile amines, ammonia and carbon dioxide prior to recording steam conductivity. This thoroughly effective steam degasser uses a cation exchange resin for the removal of ammonia, morpholine, cyclohexylamine, and reboiling for the removal of CO_2. Constant sample temperature is maintained. Taps provided for drawing sample for other analyses.

Larson-Lane Steam and Condensate Analyzers make possible rapid and accurate measurement of steam purity, completely essential for efficient boiler operation.

A smaller, less expensive unit, the CH-16 provides for removal of ammonia and amines from steam condensate without the necessity of reheating. Condenser leakage is readily detected with this model in the presence of volatile amines or ammonia.

Write today for complete technical details.

Industrial Instruments Inc.
89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 159 ON READER-SERVICE CARD

HEATERS. 16-page Catalog 975-D describes baseboard, wall insert, radiant, floor drop-in heaters, etc.—Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.

CIRCLE 354 ON READER-SERVICE CARD

THERMOSTATS. 4-page Bulletin 3000-1 describes hermetically sealed and semi-enclosed Type A Certified Thermostats.—Stevens Mfg. Inc., Box 1007, Mansfield, Ohio.

CIRCLE 355 ON READER-SERVICE CARD

BOLOMETERS & THERMISTORS. 2-page data sheet describes bolometers, barretters, thermistors and mounts used in power measuring equipment.—PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N. Y.

CIRCLE 356 ON READER-SERVICE CARD

ANALYTICAL, LABORATORY

SPECTROMETER. 4-page brochure describes A-60 Nuclear Magnetic Resonance Spectrometer.—Varian Associates, 611 Hansen Way, Palo Alto 28, Calif.

CIRCLE 357 ON READER-SERVICE CARD

pH METERS. 2-page Bulletin 719B features Model G and GS pH Meters.—Scientific and Process Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 358 ON READER-SERVICE CARD

BORON DETECTION. 8-page Bulletin CS-100 describes portable boron detector for spot checks of atmospheric concentrations, boron analyzer for measuring boron content of a liquid stream, and continuous borane analyzer for monitoring atmospheric hazard operation.—Callery Chemical Co., Callery, Pa.

CIRCLE 359 ON READER-SERVICE CARD

SPECTROPHOTOMETERS. 16-page Bulletin 735-B describes new "A" series of double-beam, ratio-recording DK Spectrophotometers.—Scientific and Process Instruments Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

CIRCLE 360 ON READER-SERVICE CARD

POLAROGRAPH. 8-page brochure describes Mark III Square Wave Polarograph used in high resolution trace analysis at concentrations down to 10^{-7}M.—Instrument Corp. of America, 516 Glenwood Ave., Baltimore 12, Md.

CIRCLE 361 ON READER-SERVICE CARD

ORGANIC ANALYSIS UNIT. 2-page bulletin describes Model 141 Safety Ignition Unit used in Schöniger technique.—F & M Scientific Corp., 1202 Arnold Ave., Air Base, New Castle, Del.

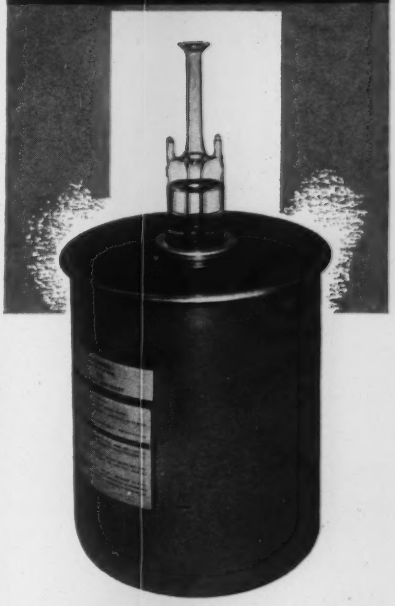
CIRCLE 362 ON READER-SERVICE CARD

DEMINERALIZERS. 6-page Bulletin 154 describes disposable cartridge-type water demineralizers.—Barnstead Still and Sterilizer Co., 2 Lanesville Terrace, Boston 31, Mass.

CIRCLE 363 ON READER-SERVICE CARD

THE EQUIPHASE* TRIPLE-POINT-OF-WATER CELL

a convenient standard for establishing a fixed temperature reference point.



EQUIPHASE Triple-Point-of-Water Cell establishes a reference temperature of 0.01°C with guaranteed accuracy of 0.0005°C. Unaffected by atmospheric pressure, contamination-free, easy and convenient to use. Just 17" high, 8" diameter.

This new laboratory standard establishes the precise point, 0.01°C, where ice, water, and water vapor coexist in equilibrium. The reference temperature point produced by the Equiphase Cell is accurate within 0.0005°C and may be quickly established with a minimum of technique or set-up.

The Equiphase Cell's accuracy cannot be easily duplicated with an ice bath. The triple-point-of-water is a physical constant — so precisely reproducible that it has been recently designated as a defining fixed point for the International Practical Temperature Scale of 1948 by the General Conference on Weights and Measures.

Reliability? Ease of use? Reasonable price? You get all these as well. But even more important — if you must have accuracy, this must be your standard.

Please write today for complete information.

*™

To put the sure in measurement

TRANS-SONICS, INC.
BURLINGTON, MASSACHUSETTS

CIRCLE 160 ON READER-SERVICE CARD

HASTINGS VACUUM GAUGES

Use Ruggedized Gauge Tubes

RUGGED **HASTINGS GAUGE TUBE UNHARMED** FROM SHOCK IN 400 LB. DROP HAMMER TEST

Ruggedness is *defined as* "strong, sturdy, hardy". But ruggedness is *demonstrated* by this shock test of a Hastings Gauge Tube conducted to government specification MIL 901B. A 400 lb. drop hammer was released to apply shocks to the above pictured Gauge Tube in all three planes from 1, 3 and 5 feet. The Hastings Gauge Tube remained unharmed and fully operable.

For every application where ruggedness, plus sensitivity, is needed in the measurement of vacuum, Hastings gauges offer advantages not found in other vacuum gauges. Their special patented heated thermopile construction, compensated for temperature and rate of change of temperature, offers rapid and accurate response. Hastings direct reading gauges, free from tube burn-out or glass breakage, are available in four hard-to-measure ranges, 0-100μ Hg; 0-1000μ Hg; 0-200mm Hg and 10-200mm Hg.

Send for Free Catalog No. 175 for more information on Hastings Vacuum Gauges, Controllers, Recorders.

HASTINGS-RAYDIST, Inc.
Hampton, Virginia PArk 3-6531

CIRCLE 161 ON READER-SERVICE CARD

DIAL INDICATORS. 10-page Bulletin ASB 300.11 describes cabinet dial and pillar dial indicators for weighing scales.—Fairbanks, Morse & Co., 19-01 Route 208, Fair Lawn, N. J.

CIRCLE 364 ON READER-SERVICE CARD

DIGITAL STRAIN INDICATOR. 2-page Bulletin 330 illustrates and describes Model 416, a calibration instrument for strain gage bridges.—Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.

CIRCLE 365 ON READER-SERVICE CARD

MANOMETERS, theory and application, are described in detail in 8-page brochure. Includes well-types, U-types, movable well-types, slant-tube types, etc.—Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.

CIRCLE 366 ON READER-SERVICE CARD

TEMPERATURE

TEMPERATURE TRANSMITTER. 8-page Specification S 630-1 outlines features and specs of filled-thermal-system pneumatic temperature transmitter.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

CIRCLE 367 ON READER-SERVICE CARD

T/C REFERENCE JUNCTIONS, 8-page booklet, titled "Thermo-Ref, Thermocouple Reference Junction," details thermocouple materials used, specs and operating characteristics.—Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif.

CIRCLE 368 ON READER-SERVICE CARD

CRYOGENIC TEMP SENSORS, 8-page Bulletin 2000 describes platinum-resistance temperature transducers for cryogenic fluids.—Trans-Sonics, Inc., Box 328, Lexington 73, Mass.

CIRCLE 369 ON READER-SERVICE CARD

CRYOGENIC INSTRUMENTATION. 6-page Bulletin CG 112R contains information on equipment to accurately measure temperatures, pressure, flow and liquid level for use in cryogenic environments.—Cryogenics, Inc., Stafford, Va.

CIRCLE 370 ON READER-SERVICE CARD

FLOW, LEVEL

LIQUID LEVEL GAGE VALVES. Two 4-page catalogs, Data Units 397 and 398, illustrate and describe features of Liquid Level Gage valves.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 371 ON READER-SERVICE CARD

VENTURI TUBE ACCESSORIES. 4-page Bulletin 110.20-2 gives description and diagrams on straightening vanes, vent cleaners, flushing devices and special chambers.—B-I-F Industries, Box 276, Providence, R. I.

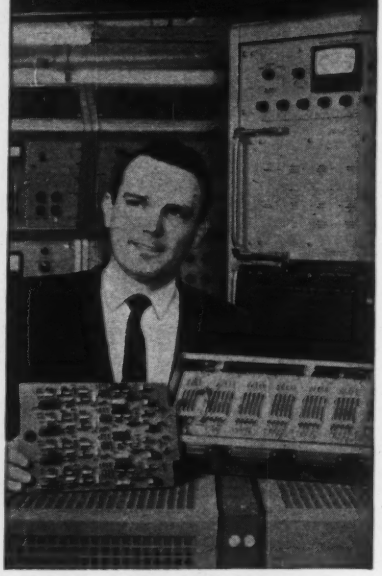
CIRCLE 372 ON READER-SERVICE CARD

LEVEL CONTROL. 4-page bulletin provides descriptive information on new Fielden Tektor capacitance-probe type level controller "without any electronics in the probe assembly."—Fielden Electronics, Inc., Huntington, N. Y.

CIRCLE 373 ON READER-SERVICE CARD

NEW

MB Automatic Spectrum Equalizer



- *Speeds Up Random Vibration Testing*
- *Eliminates Costly Set-Up Time*

MB's New Automatic Spectrum Equalizer provides automatic compensation of "random motion" system. Saves time and money in environmental testing of missile components and systems. Simply set desired spectrum shape on graphic panel in terms of power density in db, and turn the level control. The fully automatic control system assures conformity between desired and actual spectra. Tests can be rerun at a later date with assurance of identical spectral content.

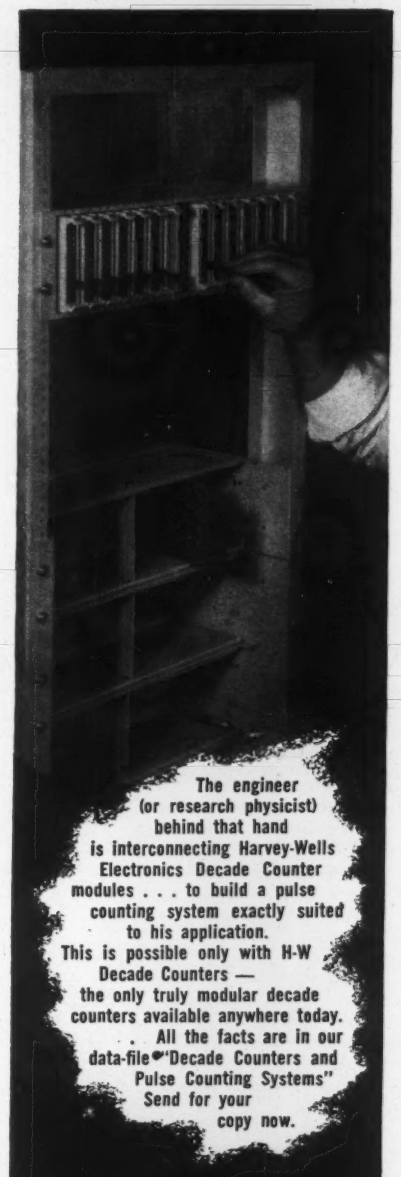
Other features include:

- High accuracy; employs 80 filters, each 25 cps wide, covering frequency range 15 cps to 2000 cps.
- Wide dynamic control range
- High stability; better than .008%/°C.
- Low distortion; less than 1.5%
- Special read-out to permit rapid analysis

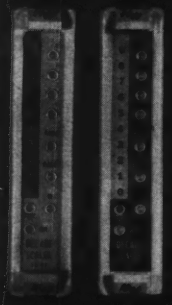
For more information, send for Bulletin 129.

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1103 State Street, New Haven 11, Conn.

CIRCLE 162 ON READER-SERVICE CARD



The engineer (or research physicist) behind that hand is interconnecting Harvey-Wells Electronics Decade Counter modules . . . to build a pulse counting system exactly suited to his application. This is possible only with H-W Decade Counters — the only truly modular decade counters available anywhere today. . . . All the facts are in our data-file "Decade Counters and Pulse Counting Systems" Send for your copy now.



Left: H-W Model 1042 10 mc Decade Counter Module
Right: H-W Model 142 1 mc Decade Counter Module

Both models have front panel outputs for: Carry signals, 8-4-2-1 logic signals, staircase voltage for driving a printer.

Harvey-WELLS ELECTRONICS INC
14 HURON DRIVE NATICK, MASS.

CIRCLE 163 ON READER-SERVICE CARD

TESTING

DIELECTRIC TESTING. 12-page Bulletin GEA-7178 describes testing equipment for use by electrical apparatus and insulation manufacturers.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 374 ON READER-SERVICE CARD

TAPE TESTER. 2-page brochure describes Model Seven Magnetic Tape Tester for preventive maintenance of computer installations and for production testing of new tape.—General Kinetics Inc., 2611 Shirlington Rd., Arlington 6, Va.

CIRCLE 375 ON READER-SERVICE CARD

D-C RESISTANCE STANDARDS. 4-page Data Sheet EB 2 (1) describes precise d-c electrical resistance standards.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 376 ON READER-SERVICE CARD

DATA HANDLING

STATISTICAL COMPUTER. Bulletin 91436 describes the Statistic, a desktop computer for statistical calculations.—Boonshaft and Fuchs Inc., Hatboro Industrial Park, Hatboro, Pa.

CIRCLE 377 ON READER-SERVICE CARD

DIGITAL INSTRUMENTATION. 20-page catalog provides descriptive information on voltmeters, frequency counters, frequency meters, time interval meters, pulse generators, etc.—Beckman/Berkeley Div., 2200 Wright Ave., Richmond, Calif.

CIRCLE 378 ON READER-SERVICE CARD

DIGITAL CIRCUIT CARDS. 4-page brochure describes Series C100 of digital circuit cards comprised of over 45 types of transistor circuit cards, for application in general and special purpose digital equipment.—Epsco, Incorporated, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 379 ON READER-SERVICE CARD

LOGIC PANELS. 4-page brochure illustrates and specifies Logic Panels, a series of 16 digital circuit modules for rapid patchwork connection of digital logic.—Epsco, Incorporated, 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 380 ON READER-SERVICE CARD

OPTICAL CODE READER. 8-page brochure illustrates, describes, and explains uses of code reading system which electronically converts imprinted code to punched input data.—Addressograph-Multigraph Corp., 1200 Babbitt Rd., Cleveland 17, Ohio.

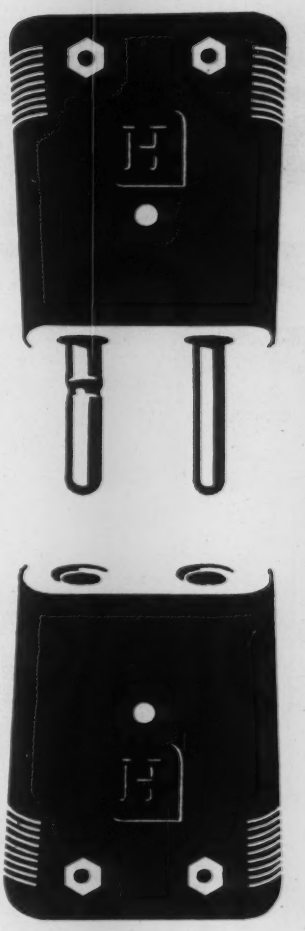
CIRCLE 381 ON READER-SERVICE CARD

TELEMETRY RECEIVER. 4-page bulletin describes with specs Type 1455 Multiple Bandwidth Telemetry Receiver.—Vitro Electronics, A Div. of Vitro Corp. of America, 919 Jesup-Blair Dr., Silver Spring, Md.

CIRCLE 382 ON READER-SERVICE CARD

TELEMETRY DATA RECORDING. 2-page Data Sheet C-025 illustrates and describes Type 1450 Pre-Detection Telemetry Receiver.—Vitro Electronics, Div. of Vitro Corp. of America, 919 Jesup-Blair Dr., Silver Spring, Md.

CIRCLE 383 ON READER-SERVICE CARD



QuiK-Konnect
PLUGS AND JACKS

New Honeywell QuiK-Konnect Plug and Jack Assemblies provide fast, foolproof connection of thermocouples to extension wire, and thermocouple extension wire to instruments. Inserts of different diameter positive and negative poles insure correct polarity every time. Inserts are easily removed for field calibration change or replacement, and can be furnished in different metals to match thermocouple alloy. Honeywell Quik-Konnect Accessories include identos, cable clamps, and tube adapters.

Get complete details from your nearby Honeywell field engineer, or write today for Specification Sheet FS 005-3. Minneapolis-Honeywell, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

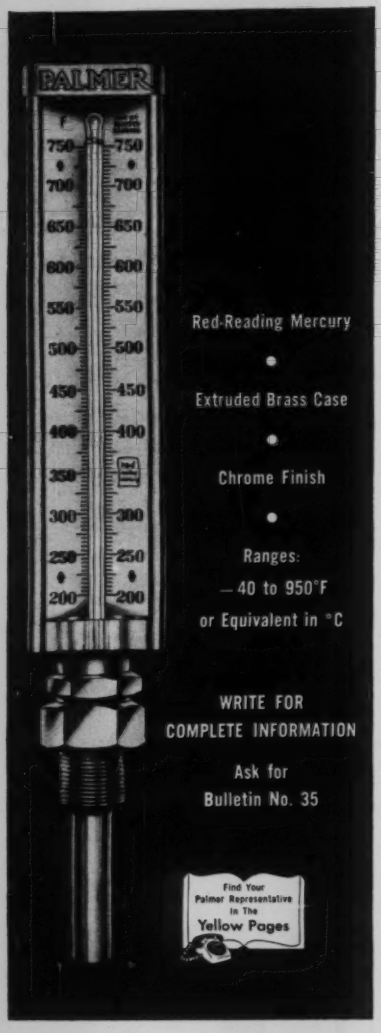
Honeywell
First in Control
SINCE 1885

CIRCLE 164 ON READER-SERVICE CARD

TODAY'S MODERN INDUSTRY
DEMANDS A MODERN THERMOMETER

PALMER

RED-READING MERCURY THERMOMETERS



PALMER

PALMER THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording
and Dial Thermometers • Cincinnati 12, Ohio
CIRCLE 165 ON READER-SERVICE CARD

DIGITAL MODULES. 12-page catalog describes and explains uses of T-PAC plug-in digital modules.—Computer Control Co., Inc., 983 Concord St., Framingham, Mass.
CIRCLE 385 ON READER-SERVICE CARD

DATA HANDLING SYSTEMS. 20-page folder "Product Digest 160" presents information on oscillographs, bridge balance units, etc.—Midwestern Instruments, 41st & Sheridan Rd., Tulsa 18, Okla.
CIRCLE 386 ON READER-SERVICE CARD

PUNCHED TAPE READER. 4-page Spec DSD-SR-16 describes and specifies Model 84 punched tape reader.—Cook Electric Co., Public Relations Dept., 2700 Southport Ave., Chicago 14, Ill.
CIRCLE 387 ON READER-SERVICE CARD

SCANNER MODULE. 2-page Bulletin DPS/A32 illustrates and describes Model SC-101 Scanner Module.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.
CIRCLE 388 ON READER-SERVICE CARD

DATA HANDLING SYSTEM. 16-page publication "Philco Bits," Vol. 2/No. 13, features the Philco 2400 low-cost, high-capacity system.—Philco Corp., Government and Industrial Group, Computer Div., 3900 Welsh Rd., Willow Grove, Pa.
CIRCLE 389 ON READER-SERVICE CARD

INPUT STATION. 2-page Bulletin DPS-A61 provides details on DL-210 General Purpose Input Station, Model 87-210-01.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.
CIRCLE 390 ON READER-SERVICE CARD

DIGITAL LOGIC PACKAGES. 6-page Catalog TS-55 describes with diagrams transistorized DigBits units.—Tech Serv Inc., 4911 College Ave., College Park, Md.
CIRCLE 391 ON READER-SERVICE CARD

DIGITAL MODULES. 12-page Catalog H contains comprehensive description and functional diagrams of 10- and 16-Mc Series H PAC's.—Computer Control Co., Inc., Framingham, Mass.
CIRCLE 392 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

DUAL TRACE SCOPE. 2-page bulletin illustrates and describes Types 1120 and 1120-R Dual Trace Main Frames as basic CR indicators without plug-ins.—Analab Instrument Corp., 30 Canfield Rd., Essex County, Cedar Grove, N. J.
CIRCLE 393 ON READER-SERVICE CARD

ELECTRONIC VOLTMETERS. 8-page 1961 Short Form catalog illustrates and specifies 12 voltmeters in the 300 Series (including new Model 350), and signal generators, inverters, converters, decade amplifiers, etc.—Ballantine Laboratories, Inc., Boonton, N. J.
CIRCLE 394 ON READER-SERVICE CARD

IMPEDANCE BRIDGE. 4-page Catalog Sheet C-13 describes Model 291-A Universal Impedance Measuring System for high-accuracy measurements of resistance, conductance, inductance, capacitance, etc.—Electro Scientific Industries (formerly Electro Measurements) 7524 S. W. Macadam Ave., Portland 19, Ore.
CIRCLE 395 ON READER-SERVICE CARD

TUBING TO MEET ALL SPECS .010" TO 1.000"

● Name your needs in accurately drawn seamless brass, copper, aluminum, nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver, and we have your answer.

BOURDON tubing in constant wall thickness . . . consistent spring properties . . . exact duplication. Precision Bourdon Tubing is available to your particular specifications.

COAXITUBE is a metal shielded wire consisting of an inner conductor, insulation and seamless non-ferrous metal tubular shield forming a coaxial pair of conductors. Semi-rigid equivalents to all RG/U cables.

POINTER TUBING light enough to react to slightest torque impulse, yet strong enough to withstand striking the stop pin. Sizes to 0.010" O.D., wall thickness down to 0.0010".

Whatever your designs and plans for tubing you can rely on Precision for finish, accuracy and quick deliveries. Write for folder "Small Tubing For Industry" to Department 1, Precision Tube Co., North Wales, Pa.

PRECISION TUBE COMPANY

CIRCLE 166 ON READER-SERVICE CARD

MATHEMATICAL MACHINES, Vols. I & II

By Francis J. Murray. Designed for scientifically-trained individuals in every field, this exhaustive work reflects the vital contribution of mathematical machines to science and technology. Vol. I discusses the basic principles of digital computers, stressing fundamental ideas rather than engineering detail. It considers such devices as registers, counters, adding machines, automatic calculators, punched card machines and automatic sequence calculators. Vol. II examines three categories of machines which use the principal of analogy. Continuous computers and true analogs are covered in the first two parts, while the third presents procedures and designs permitting relatively simple devices to accomplish advanced computations. *Vol. I, $12.50; Vol. II, $17.50; The set, $30.00.*

Columbia University Press
2960 Broadway,
New York 27, N. Y.

CIRCLE 168 ON READER-SERVICE CARD

Solid State Differential
Battery Operated

OPERATIONAL AMPLIFIER

In Stock

Model 203 Condensed Specifications:	
O.C. Voltage Gain:	10,000+
S.C. Current Gain:	100,000+
Common Mode Rejection:	10,000+
Output:	±5 volts at 10 m.a.
Common Mode Input: Full Output to 10 KC min.	±5 volts
Unity Gain Bandwidth:	500 KC at reduced amplitude
Voltage Drift:	less than 1 millivolt per day under laboratory conditions
Quiescent Power:	2 m.a. at 18 volts

Two Internal 9 volt batteries provide up to 200 hour battery life.

We offer a number of plug-in units for fixed functions. Write for complete specifications.

Monroe

ELECTRONIC LABORATORIES, Inc.
39 Vernon Street • Middleport, New York

CIRCLE 169 ON READER-SERVICE CARD

OSCILLOSCOPE. 8-page booklet gives a detailed presentation of high-speed laboratory oscilloscope, Type 519.—Tektronix, Inc., Box 500, Beaverton, Ore.

CIRCLE 396 ON READER-SERVICE CARD

RECTANGULAR METERS. 4-page data sheet shows outline drawings of Style 65 meter and lists the 95 ranges available as a-c and d-c voltmeters, ammeters, milliammeters, and microammeters.—Helipot Div. of Beckman Instruments Inc., Technical Information Service, 2500 Harbor Blvd., Fullerton, Calif.

CIRCLE 397 ON READER-SERVICE CARD

THREE-DIMENSIONAL TV. 2-page Data Sheet illustrates and describes features of a Stereo-Television Kit, which converts any closed-circuit television to a 3-D picture with no electronic modification.—Stereotronics Corp., 1717 North Highland Ave., Los Angeles, Calif.

CIRCLE 398 ON READER-SERVICE CARD

NUCLEONICS

NUCLEAR DENSITY GAGING. Two 2-page specification sheets, Bulletins ASR-3 and LASR-3, describe features and characteristics of nuclear density measuring gages.—Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio.

CIRCLE 399 ON READER-SERVICE CARD

ATOMIC ABSORPTION. 4-page Bulletin 6-2000 describes unique design features and advantages of Optica A7-6 Atomic Absorption Apparatus.—Optica Inc., 830 Evarts St., N. E., Washington 18, D. C.

CIRCLE 400 ON READER-SERVICE CARD

NMR ANALYZER. 12-page brochure on the Schlumberger NMR (nuclear magnetic resonance) Analyzer and its applications is available from Ridgefield Instrument Group, Schlumberger Corp., Ridgefield, Conn.

CIRCLE 401 ON READER-SERVICE CARD

MISCELLANEOUS

SPEED MEASUREMENT SYSTEMS. 12-page Bulletin GEZ-3251 describes complete line of a-c and d-c tachometer generators and indicators.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 402 ON READER-SERVICE CARD

PLASTIC TUBING. 4-page bulletin and price list give data on Tuff-Tube PVC high-pressure tubing.—Extron Corp., 3600 Pleasant Ridge Rd., Knoxville 21, Tenn.

CIRCLE 403 ON READER-SERVICE CARD

PERCENT MOISTURE. 8-page king-size brochure describes with pictures and diagrams Qualicon process instrumentation for measurement and control of % moisture and bulk density in solids, liquids, and slurries.—Nuclear-Chicago Corp., 333 East Howard Ave., Des Plaines, Ill.

CIRCLE 404 ON READER-SERVICE CARD

VIBRATION METER. 4-page Bulletin PR-9252 describes battery-operated, hand-carried vibration meter with high-gain, transistorized circuitry.—Korfund Co., Inc., 86A Cantiague Rd., Westbury, N. Y.

CIRCLE 405 ON READER-SERVICE CARD

If you use an oscilloscope, chances are 4 out of 5 that you need the ROTEK

AC/DC to DC COMPARATOR

TRANSISTORIZED AND MILITARIZED

0.005% COMPARISON ACCURACY AC TO DC

0.001% COMPARISON ACCURACY DC TO DC

FOR
- DYNAMIC PRECISION WAVEFORM ANALYSIS
- AC CALIBRATION
- DC CALIBRATION

The Rotek AC/DC to DC Comparator converts any oscilloscope into a precision waveform analyzer, enabling accurate observation of small, selected portions of large waveforms without oscilloscope overload. For the first time, precision AC versus DC waveform comparison can also be made. The Comparator permits ready examination of AC cycle-to-cycle bounce, modulation, and drift on an oscilloscope, as well as determination of DC amplifier or system low frequency bounce and drift at nonzero outputs.

Please write for Bulletin 212

Other Rotek instruments:
AC Voltage Standards
DC Voltage/Current Standards

ASK FOR DEMONSTRATION

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Kirkland 7-0175

CIRCLE 170 ON READER-SERVICE CARD

SEARCHLITE SECTION

IDENTICHARTS
for easier, more accurate chart interpretation

ROYSON IDENTICHARTS provide remote control printing of sequence numbers, counter readings, time and date, code symbols or other data on strip charts for faster, more accurate interpretations. Write or call

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HATBORO, PA. OSborne 5-2800

CIRCLE 171 ON READER-SERVICE CARD

TUBULAR RHEOSTATS
Toroid
Winding Machines
REX RHEOSTAT CO.
149-d Babylon Tpke. Roosevelt, L. I., N. Y.

CIRCLE 172 ON READER-SERVICE CARD

FERRANCE BEAM COMPASS
SOLVES Your CIRCLE PROBLEMS
SAVE TIME and MONEY
Beam lengths from 7" to 78½" one piece anodized aluminum. Couplers available in Aluminum, Nylon, or attractive Plastic. Sets available, individually priced from $3.45 or made up to individual requirements. (15% quantity discount on 3 or more sets)
NON-SLIP "GRIP-RINGS" furnished with all points.
Send for Circular and Price List Today
FERANCE Construction Co.
28 Woodside Drive • Penfield, N. Y.

CIRCLE 173 ON READER-SERVICE CARD

Model HT-12 Four-Range Tachometer
Centrifugal tachometer that measures revolutions per minute and surface speeds.

TOTAL RANGE: 90-12,000 RPM
1st — 90-360 RPM
2nd — 300-1200 RPM
3rd — 900-3600 RPM
4th — 3000-12000 RPM
Feet per minute—one half the dial reading with use of 6" disc wheel.

Advantages: Accuracy—±0.5% • Stop button feature • Instantaneous readings • 3" easy to read dial • Light—approx. 14 oz

Kernco Instruments Co., Inc.
Box 1284, Church St. Station
New York 8, N. Y

CIRCLE 174 ON READER-SERVICE CARD

GLASS AND GLASS-CERAMICS. 68-page illustrated booklet reviews history of glass, details basic types, describes expanding role of glass in science, industry, electronics, etc.—Corning Glass Works, Corning, N. Y.

CIRCLE 406 ON READER-SERVICE CARD

LOW-NOISE AMPLIFIER. 2-page brochure describes a transistorized, high-gain, low-noise amplifier, Model 203.—Quan-Tech Laboratories, Inc., Boonton, N. J.

CIRCLE 407 ON READER-SERVICE CARD

The following catalogs may be obtained by requesting them on company letterhead.

MINIATURE BALL BEARINGS. 64-page Catalog 6 furnishes complete information on more than 500 types and sizes of miniature and instrument size bearings. Contains technical handbooks data.—Write to William F. Hutchinson, Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.

CIRCLE 411 ON READER-SERVICE CARD

ELECTRONIC TEST INSTRUMENTS. 220-page 1961-Catalog contains illustrations, specs, and descriptions of oscilloscopes; oscillators; signal generators; voltmeters, ammeters, ohmmeters; microwave equipment, etc.—Write to Harry J. Lewenstein, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.

CIRCLE 412 ON READER-SERVICE CARD

MASTER POWER CONTROL BOX

Panel Mounted Fuse
On-off Switch
Pilot Light
Six Long Life Replaceable Sockets
Silver Gray Hammertone Case
Mounting Ears
Model 20— $6.75
10 ft. U/L Neoprene Heater Cord
Molded Plug
15 Amps 130 Volts
Send for literature
"U" GROUND MODEL $8.50
Quotations on special units on request.
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REBUILT INSTRUMENTS
Many Temperature Controllers, Precision Indicators, Continuous Line & Multiple Point Recorders; Leeds & Northrup Speedomax, Micromax; M.H. Brown Electroniks, and other makes. Also Strain Gauge Recorders & Potter Flow Recorders & Indicators.
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1205 Lemar St. • Dayton 4, Ohio
BA3-2241

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FIXED SET THERMOSTATS
ANY SIZE, ANGLE OR USE
SETTING RANGE: —35°C to 370°C
SET SENSITIVITY: ±.01°C
Guaranteed sensitivity . . . year-in, year-out reliability . . . accurate control of temperature in ovens, electronic equipment, baths, ducts, freezers, fire alarms, incubators, analytic instruments, etc. Triple distilled mercury; filled at still. Hermetically sealed with dry hydrogen at 75 psi. Calibrated to Bur. Standards accuracy. Priced 10% to 15% lower than competitive lines.
FREE CATALOGUE WRITE.
PHILADELPHIA SCIENTIFIC GLASS CO.
RIDGE AVENUE, PERKASIE, PA.

CIRCLE 176 ON READER-SERVICE CARD

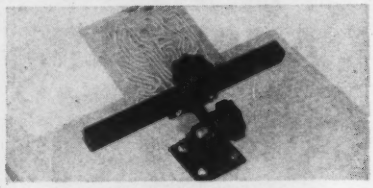
MACK
Thermo-Alarm
Gives visible and audible warning of dangerous temperature change in refrigerated or heated compartments.
Write for free Bulletin
MACK ELECTRIC DEVICES, INC.
Wyncote, Pa. TUrner 4-8123

CIRCLE 177 ON READER-SERVICE CARD

SMITHS TACHOMETERS
For Precise and Rapid Measurements of
SHAFT SPEEDS CUTTING SPEEDS SURFACE SPEEDS
- Magnetic Design Steady readings accurate to ±0.5%
- Self-Powered Needs no battery.
- Hold Button
- Overspeed Protection Inherent
- Instantaneous Reading No timing
- Nine Ranges

Complete Service Facilities — Send for Details and Literature
CLARENCE J. MARX CO.
Box 4033, Cleveland 23, Ohio

CIRCLE 178 ON READER-SERVICE CARD



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for Printed-Circuit Boards
A convenient inexpensive method for holding P.C. boards during assembly and hand-soldering operations. Takes boards up to 12" or longer. Can be rotated in arc in excess of 180 degrees. Completely accessible on both sides. Constructed of black-anodized aluminum with bakelite knobs. Mounted on Formica board.
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Western Electronic Products Co.
2420 North Lake Avenue, Altadena, Calif.

CIRCLE 179 ON READER-SERVICE CARD

Representation Wanted
New unit control valve, barstock valves. Sensational savings for continuous processing services. Exclusive franchised distributorships available.
1011 West York; Enid, Oklahoma

INDUSTRY NEWS

PERKIN-ELMER announces election of *Robert E. Lewis* as president and chief executive officer, and a director of the corporation.

Robert E. Lewis

H. H. Gorrie

L. F. Richardson

BAILEY METER announces three executive promotions: *H. H. Gorrie* has been elected executive vice president; *L. F. Richardson*, vice president in charge of sales activities and a member of the Board of Directors; and *J. H. Dennis*, vice president in charge of all manufacturing activities and plants.

MINNEAPOLIS-HONEYWELL announces appointment of *John B. Moxness* as manager of pyrometer supplies for the Brown Instruments Division.

PENN INSTRUMENTS DIVISION, of Burgess-Manning recently was sold to **PENN METER COMPANY** of Philadelphia.

Ralph E. Hall

Dr. Ralph E. Hall, director emeritus of Hagan Chemicals & Controls, Inc., died May 2, at his home in Rehoboth Beach, Del. at the age of 76. Dr. Hall founded Hall Laboratories, a division of Hagan in 1925. In more than 30 years in the field of physical chemistry, he received 54 patents in the United States and 6 other countries, especially for the chemical treatment of boiler water.

James D. Dunlap

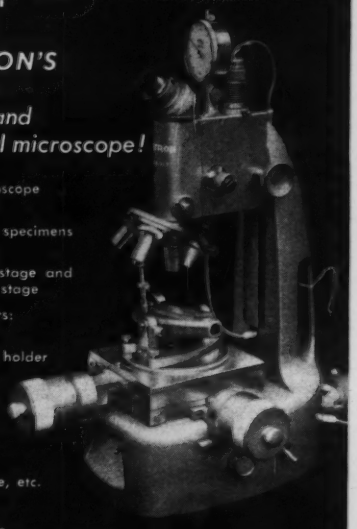
James D. Dunlap, 46, metals market manager for Minneapolis-Honeywell Regulator Company's Industrial Products Group, died April 23, 1961 of a heart attack. For several year he had held the same position with the Brown Instruments Division.

Joseph F. Sullivan

Joseph F. Sullivan, for many years advertising manager of Brown Instruments division of Minneapolis-Honeywell Regulator Company, died April 24, 1961 of a heart attack. He was 63 years old. At the time of his death he was advertising production manager of Honeywell's Industrial Products Group. In 1938 he launched the well known Brown Industrial Calendar. He also founded *Instrumentation*, the well-known company-sponsored quarterly publication.

MEASURE IN 3 DIMENSIONS TO 0.0001"

with UNITRON'S Combination Toolmakers and Metallurgical microscope!



- Direct reading from microscope screws and dial indicator
- Examines polished metal specimens at 30X, 100X, 400X, etc.
- Ball bearing rectangular stage and calibrated circular rotary stage
- Three separate illuminators: substage, surface, vertical
- Inclinable work and tool holder
- Accessories include viewing screen for contour projection and optical comparison, eyepiece scales for measuring screw threads, diameters, metal grain size, etc.

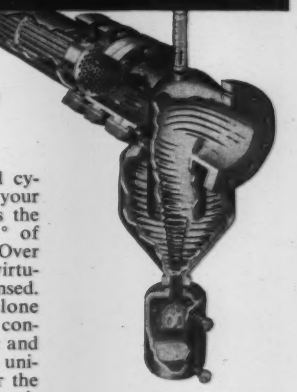
Even the smallest shop can rapidly pay for this versatile instrument in time and materials saved. UNITRON Model TM, with all its features, costs about the same as the lowest priced, simple shop microscope. .....fob Boston only **$1050**

Write for Bulletin TM 22 Q

UNITRON INSTRUMENT COMPANY • MICROSCOPE SALES DIV 66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

CIRCLE 180 ON READER-SERVICE CARD

CUT COSTLY INSTRUMENT MAINTENANCE



with Clean Dry Oil-Free Compressed Air

An Adams aftercooler and cyclone separator installed in your instrument air supply cools the discharge air to within 2° of cooling water temperature. Over 90% of the moisture and virtually all of the oil are condensed. The exclusive Adams cyclone separator then removes the condensed liquid oil and water and other foreign material with uniform high efficiency — over the entire operating range. This air is entirely suitable for air motor and most control applications. When bone dry air is needed, the chemical drier load is then limited only to polishing action, since the bulk of the moisture will have been removed by lower cost condensation. Why not review the cost cutting advantages of an Adams aftercooler-separator combination? Ask today for your free copy of Bulletin 715. R. P. Adams Co., Inc., 262 East Park Drive, Buffalo 17, New York.

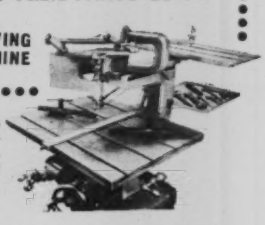
ADAMS QUALITY COMES THROUGH

CIRCLE 181 ON READER-SERVICE CARD

how to ENGRAVE PANELS & SIGNS to 30" wide by any length

Use the **LOW COST** *precision built* **PREIS-PANTO 2D-4**

ENGRAVING MACHINE



It does the work of larger machines, costing much more.

- Pantograph is graduated with reductions from 1:1 to 100:1 and will reduce to any size to infinity.
- Pantograph and spindle link joints equipped with precision ball bearings throughout.
- Precision ball bearing cutter spindle.
- Collet capacity from 1/10" to 1/4" and standard taper shank cutters.
- Six spindle speeds—5,000 to 14,000 rpm.
- All feed-screw dials graduated in .001".

TRADE MARK PANTO

Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS ENGRAVING MACHINE CO.
661 U. S. Highway 22, Hillside, N. J.
CIRCLE 182 ON READER-SERVICE CARD

Shore

HARDNESS TESTING

The Shore Scleroscope for testing the hardness of metals and other materials. Accurate, rapid, completely portable, non-marring. Over 40,000 in use. Pioneer American standard since 1907.

The Shore Durometer for testing the hardness of rubber and rubber-like materials. May be used free hand or mounted on Operating Stand. Conform to ASTM D676, D1484, & D1706.

Shore

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90-35 VAN WYCK EXPRESSWAY
JAMAICA 35, N.Y., U.S.A.

CIRCLE 183 ON READER-SERVICE CARD

I&CS ADVERTISERS' INDEX

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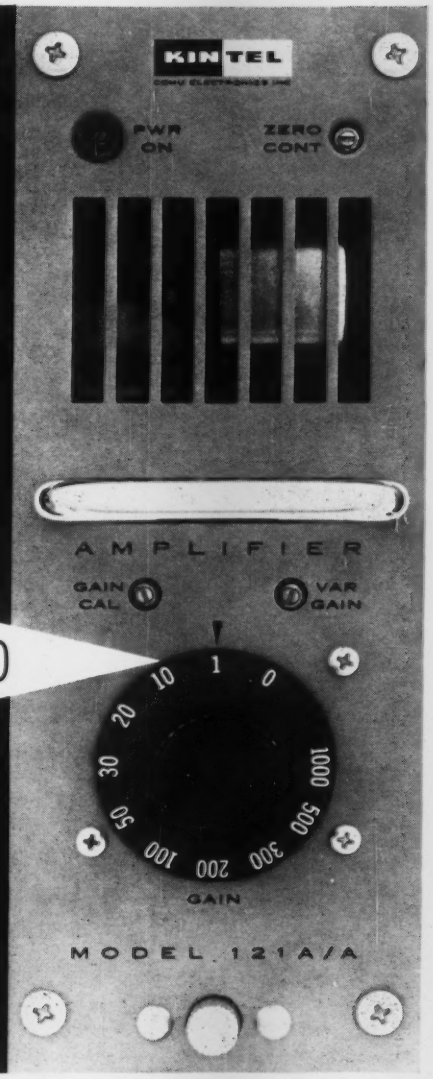

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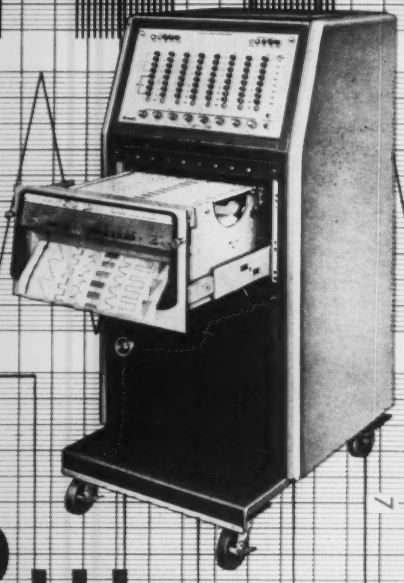

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